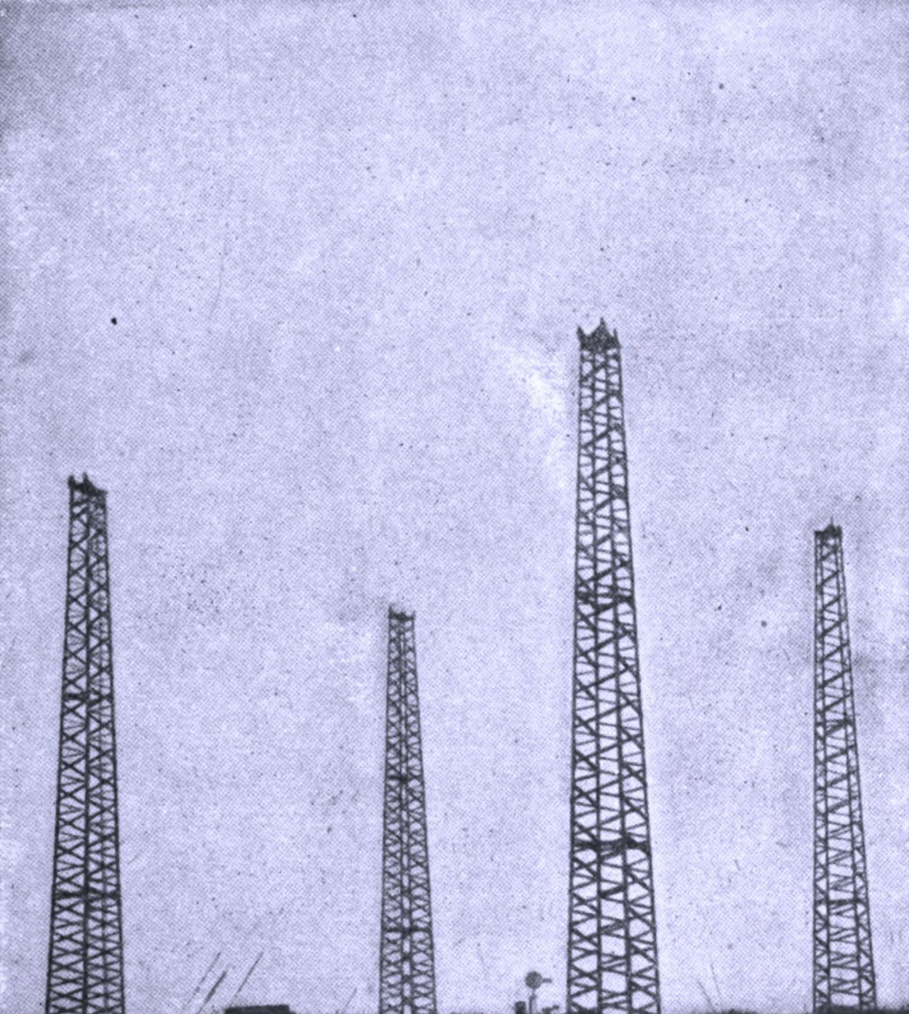
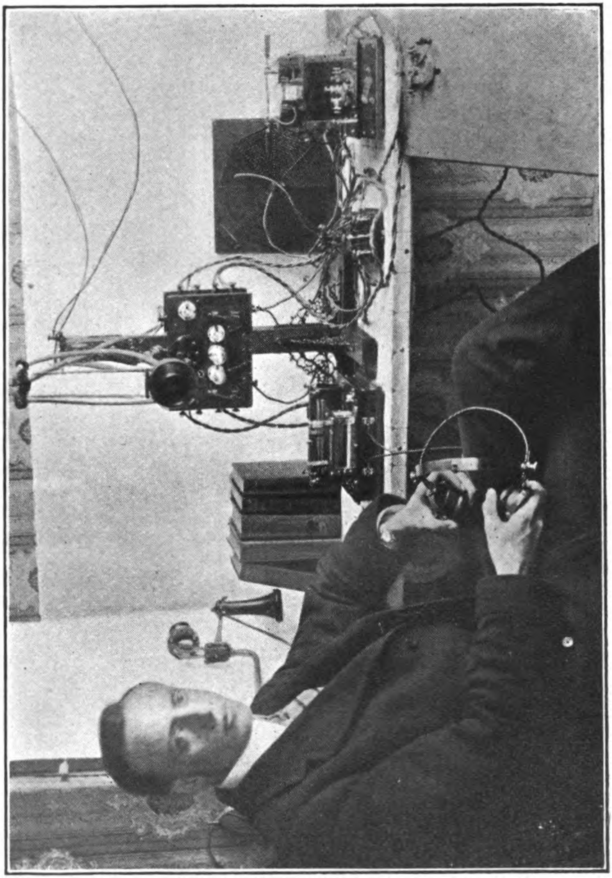


The wireless operators' pocketbook of information and diagrams

L. Wilbur Bishop



THE Wireless Operators' Pocketbook

OF

INFORMATION AND DIAGRAMS

BY

LEON W. BISHOP

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PREFACE

The purpose of this little manual is to satisfy the desires of the wireless operator and of those experimenters who have already some knowledge of wireless phenomena, and who wish for a practical book more suited to their needs than the many elementary ones which deal mostly with the construction of simple apparatus, or the elaborate technical and mathematical treatises which presuppose a technical education to understand them. Although some acquaintance with wireless apparatus is expected, it has been the author's intention to give enough of the theory of the circuits and of each piece of apparatus so that anyone interested may understand it and its working.

So far as is possible it has been intended to take up the various subjects in their logical order, except perhaps where a purely logical order would not at the same time aid in the general clearness of explanation. The treatment of the transmitting and receiving instruments, the ground and the aerial connections, naturally comes before the more general chapters. The chapters descriptive of instruments are also noticeably more simple than those towards the end of the book, where a further familiarity with the author's expression is

expected. Moreover, it is to be noticed that although most of the popular forms of instruments are mentioned and described, some have been omitted. This has usually been intentional, in order to comprise within the smallest possible space the description of late types of apparatus, and that of the most approved and efficient design.

The author's knowledge of wireless is based largely on his experience in the Stone Company, and under the direction of Mr. John Stone Stone. He is also largely indebted to Mr. G. W. Pickard for information during the writing of this book. Both Mr. Stone and Mr. Pickard have freely allowed the reproduction of their circuits and theories. On telephony, he is also indebted to Mr. Lee DeForest and others. Thanks are by this means extended to those whose names are mentioned and to many others for help received, either personally or from their printed works.

CONTENTS

WIRELESS OPERATORS' POCKETBOOK

CHAPTER I

THE TRANSMITTING CIRCUIT

WIRELESS communication is accomplished by means of vibrations set up in the ether by a set of special instruments used for creating and transmitting them. These vibrations, which travel in all directions away from the sending station in the form of waves, are created of a certain length and frequency by the action of a number of different instruments, each of which affects the wave-creating current in a definite manner. If, for instance, we take the following schematic diagram of the transmitting apparatus, we may understand the part played by each instrument toward the desired result of producing intelligible effect upon telephone receivers at any station.

An electric current, set up by the batteries of the primary circuit, passes through the primary winding of the spark coil. This would form a closed circuit, except for the fact that a telegraph key, connected between batteries and primary, allows the operator to make and break the flow of current at his own will. When the key is held down for an instant only, the

current flowing through the circuit makes a telegraphic "dot." If held down for a longer period, we have a telegraphic "dash." It is thus the will of the operator which controls the flow of current through this primary circuit, transferring his thoughts, by means of an established code, to the receiving station.

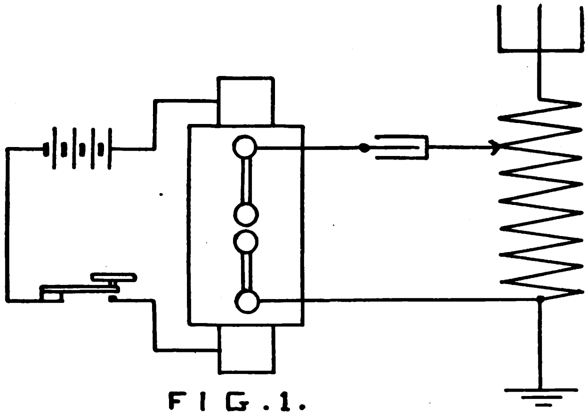

FIG. 1.

The current of our primary circuit is direct. There must, however, be alternating current for the secondary. Therefore some form of interrupter must be placed in the primary circuit in order to break the current and to give it the necessary pulsations. A mechanical vibrator connected to the primary of the spark coil is most frequently used, although an electrical interrupter on a separate battery circuit may be employed instead.

This *Vibrator* interrupts the steady current in the primary of the spark coil, varying the magnetism of the core, by constantly changing its polarity. The secondary of the coil picks up the magnetism; and because the number of turns of wire on a secondary are proportionately greater than on a primary, the

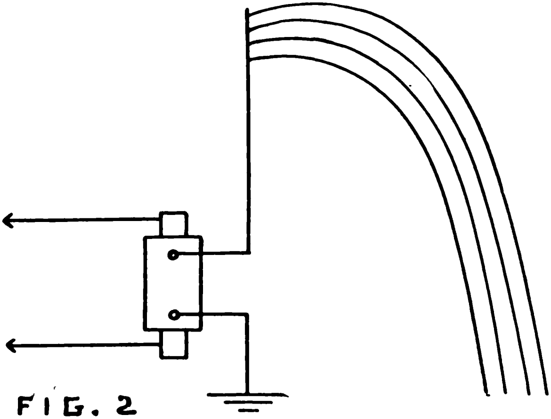

FIG. 2

secondary transforms this magnetism into a current of higher voltage. Whereas we had in the primary circuit a direct current of low voltage, we have now in the secondary an alternating current of high voltage.

The current rushes into the aerial, filling or charging it, and this charge creates an electro-static field around it. Now, if the current ceases to flow, the lines of force of this field will fall flat. We then place a spark

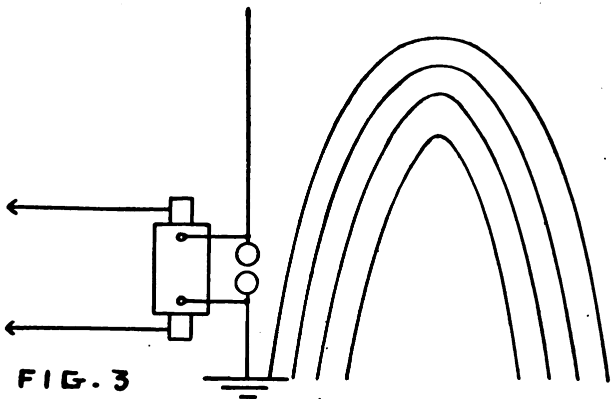

FIG. 3

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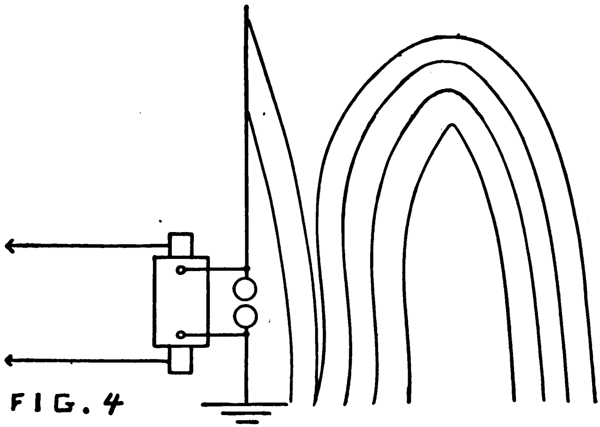


FIG. 4

gap between aerial and ground. Now, when the aerial charge is great enough to overcome the resistance of air between the points of the spark gap, a spark will jump between them, thus discharging the aerial abruptly and jerking the lines of force sharply to the ground. The repeated charge of the aerial and its

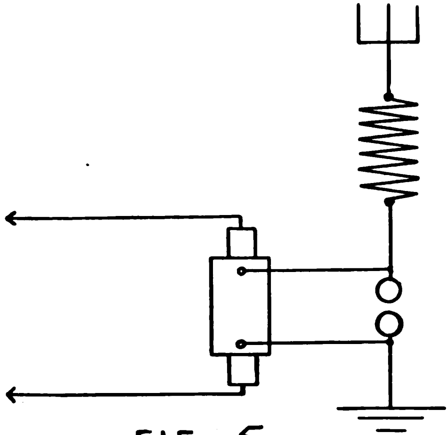


FIG. 5

repeated discharge through the spark gap will snap off portions of the field, detach them from the aerial, and thus form electric waves. Series or trains of these detached waves follow one another with great velocity, travelling at the same speed as light (186,400 miles per second).

Instruments connected according to Figs. 3 and 4

will transmit messages into space, but our wave frequency will be very high, and therefore the wave length will be very short. Now short waves are especially liable to all influences tending to shorten their lives — to absorption by the neighboring hills and trees, to reflection and refraction, which tend to change their direction, and to polarization or complete annihilation.

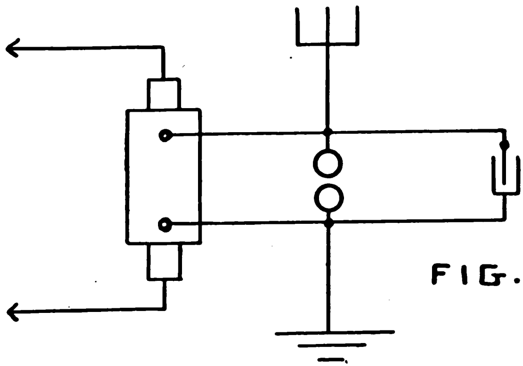


FIG. 6

Therefore short waves are inefficient for transmission to any distance. In order to lengthen the waves, we must decrease their frequency. If a coil is placed in the aerial (between spark gap and aerial) it will produce this effect, and the waves will be lengthened. A condenser across the spark gap will produce a similar effect in lengthening the waves. By combining the two, using both coil and condenser, we will add together the two effects. Not only can we obtain

the desired long waves in the manner shown in Fig. 7, but coil and condenser may be placed in series (see Fig. 1), with the same results; or they may be connected as shown in Fig. 8. Usually it is considered best to have both devices together. Thus is formed a resonance or oscillatory circuit, in which the amount

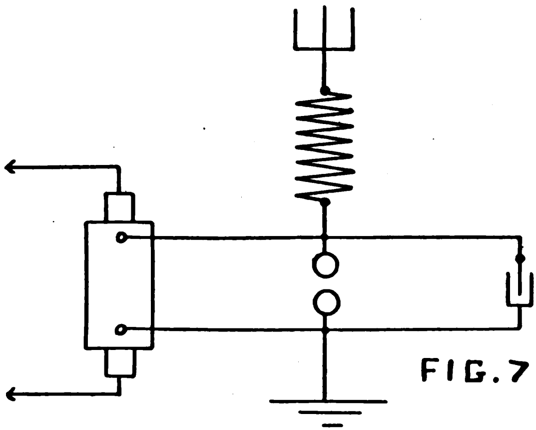


FIG. 7

of inductance and capacity (*i.e.* of coil and condenser) offers a path for a spark discharge of a certain periodicity; that is, of a definite wave length and frequency. It is to be noted that under normal conditions the aerial acts as a condenser, aerial being one plate and ground the other.

Thus are formed the simplest forms of transmitting circuits. An oscillation transformer will give us

an additional circuit, which with coil and condenser balanced with the first circuit will again be in resonance. By substituting an oscillation transformer for a helix, we do not really change the circuit formerly used, we merely separate the primary entirely from the secondary, while both of them existed on the helix.

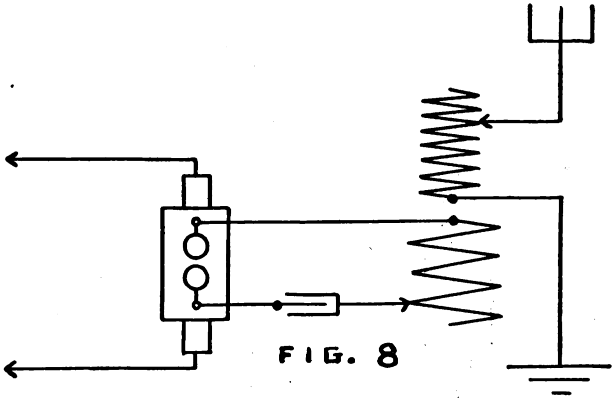


FIG. 8

By separating them completely we gain an additional variation, that of the distance between the two coils, the *coupling*. If these coils are drawn far apart, the tuning is made very sharp, the signals can only be received when the oscillation transformer used in the receiving station has a carefully ascertained amount of primary, secondary, and coupling. Such an arrangement of the oscillation transformer at the sending station would be ideal, if it were not for the fact that

more energy is lost when the coils are at a great distance apart, and consequently the transmitting distance of the station is lessened. However, if the coils are too near together, there will be another set of waves formed, following the first, but with crests between. This second tuning point will detract from the strength of signals at the first point, and as a consequence the receiving station will get its signals less clearly.

CHAPTER II

TRANSMITTING STATIONS: EXPERIMENTAL OR LOW-POWER APPARATUS

The experimenter's station will usually consist of the following pieces of apparatus for transmitting:

Batteries	Spark Gap
Telegraph Key	Condenser
Spark Coil	Helix

The Primary Circuit. Batteries are the most available source of power unless the electric light current is already installed in the house. For low-power apparatus, the dry battery is most commonly used, is fairly cheap, and requires little or no care. The Storage or Edison-Lalande cells are more efficient, and cheaper in the long run, even if somewhat more trouble to handle and keep in order. The advantage of any one of these over the ordinary wet batteries is that the amperage is higher, and high amperage is necessary to operate a spark coil.

In selecting dry batteries, the best one for wireless work will have only a moderate amount of amperage, however; say, 18 to 22; and not a high amperage of

from 30 to 35, as the latter deteriorates much more rapidly. In order to get the best and most lasting results, the cells should be connected in series multiple. Thus the amperage of the number in multiple is larger and the voltage is less than when connected in series. Only a storage cell of a known make should be used, as a poor one will prove very expensive to maintain. The storage battery has the decided advantage over the dry battery that its output is always even.

Telegraph Keys in regular use by commercial companies are adapted for wireless work. Either the leg or the legless type is well suited to all requirements. Platinum contact points are essential and are usually found on commercial types of keys. For the rest, easy action and capability of fine adjustment are all that need be looked for in buying one.

The Spark Coil increases (or technically speaking, "steps up") the voltage in order to charge the aerial, and thus to create around it an electro-static field which is to be broken down by the spark gap. A good coil is more cheaply bought than made, except in the larger sizes. Such a coil, to be thoroughly reliable, must be carefully constructed; and it is difficult for the experimenter to use all the precautions necessary to avoid loss of energy. A coil of good efficiency is built with a primary of two layers of nos. 14 to 18 single covered copper wire, wound on a core of soft drawn iron wires. The secondary is wound with a very fine wire, nos. 34 to 38, and carefully

insulated. Enamelled wire in coils, as on most pieces of wireless apparatus, is not satisfactory; the weather is apt to affect the enamel, crack it, and thus spoil its insulating qualities.

Coils are classified by the manufacturer according to the distance the spark will jump. This jump spark is long and thin, and is unsuited for wireless work. For this purpose, a short thick spark, demanding a relatively high amperage is necessary, the same names are applied, however contrary they may seem to the facts of the case. Thus, a one-inch coil, suitable for wireless, should give a one-half inch spark, sufficiently thick and hot to ignite a piece of paper placed between the sparking points. This short thick spark is called the "caterpillar spark." In buying a coil, a good test is to draw out the spark to the breaking point. If good, the discharges should then sound very sharply. This loudness of discharge, together with the hot caterpillar spark, shows the coil adapted for wireless work.

The Vibrator interrupts a current in the primary of the spark coil, thus producing magnetism on the core, which is picked up by the secondary. To give satisfactory results, a coil must have a good vibrator. Such a vibrator should have either platinum or iridium contacts, and the larger the better. The vibrator giving a high-pitched spark is much better than a vibrator giving one of low pitch. Not only does it give more current to the primary, but it causes

a spark which is more penetrating, is more easily read, and at a greater distance. Such a vibrator is by all means the one to choose, even although it consumes the battery current somewhat more rapidly than one of lower pitch.

All commercial spark coils are fitted with a *condenser* across the vibrator to stop the sparking at the vibrator contacts. By this means the current is abruptly broken, and thus the interruptions are sharper. Such a condenser is very essential, and must be carefully

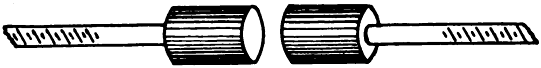


FIG. 9

fitted in capacity to the vibrator by an expert. It is not well to tamper with it or to change its value.

The Spark Gap discharges the charged aerial, and thus creates a series or train of electro-magnetic waves. The electrodes of a good spark gap are of the utmost importance, both as to their form and as to the material of which they are made. The best form for the electrodes is that of a flat-faced circular rod. A sharply pointed or spherical electrode wastes energy and is less desirable. As to materials, silver is best of all, because while it is an excellent conductor when new, the oxide forming when it becomes black is almost as good a conductor as the pure silver. Moreover, silver

is less apt to allow an arc to form across the gap. Pure tin also forms a good electrode. For general use, a commercial compound known as nickel-steel may be recommended. There is no difference between the horizontal and the vertical types in efficiency, although one should always choose the Gap with the finest adjustments.

The Condenser is a unit of balance in the transmitting set. The aerial, helix, and condenser must all be brought into resonance in order to transmit the waves to greater distances. This finding a point of resonance is the important thing. Almost always the condenser is of a fixed value, although it is possible to have it variable instead of the helix, as is usual. Transmitting condensers consist generally of glass plates and tin-foil. The glass margin around the tinfoil should be wide enough to prevent sparking over the edges. The capacity of the condenser should be sufficiently large to balance with the rest of the circuit. Leyden jars are also used as transmitting condensers, although some energy may be lost in this type by a brush discharge around the upper edges of the jar.

The Helix is another unit of balance in the set. As already stated, it is oftenest the helix which is varied when bringing the helix, condenser, and aerial into resonance. A helix of soft-drawn strip copper on hard rubber posts is the best one; but if built of copper tubing or heavy wire (the soft-drawn is always best), and on insulated wooden posts, it will be satisfactory

for low-power stations. Helices for this work should have one stationary and two variable contacts.

Having completed the general description of the qualities of the instruments in a transmitting set, it will be advisable to show a selection of instruments which will work harmoniously together. The first transmitting set usually depends upon a one-inch spark coil, and so that will be our starting point.

Transmitting Set No. 1. With a one-inch spark coil, provided with a good high-pitched vibrator, there will be necessary from six to twelve dry cells. Six cells will run the coil, but of course the energy will be greater with more. A greater number than twelve, however, should not be used, as it may break down the secondary winding and burn out the primary. An ordinary telegraph key, such as can be purchased for about a dollar, will give good satisfaction. A spark gap with silver points may be mounted on the coil or on a separate base. The transmitting condenser should consist of from ten to fifteen 5 by 7 glass plates and a suitable amount of tinfoil or leadfoil, with good margins. A simple home-made helix, made either of strip copper or copper wire, wound in a spiral or on a drum, will be all that is necessary. With an aerial of fair size and a good ground connection, this set of apparatus will transmit signals to a distance of from four to seven miles over land, or a somewhat greater distance over water.

Transmitting Set No. 2. A two-inch spark coil,

with a good vibrator, should give a hot caterpillar spark which will ignite a piece of paper when the sparking points are from one inch to an inch and a quarter apart. Such a coil requires from ten to twenty-four dry cells, or a storage battery of ten to fifteen volts, sixty ampere hours. The same key used for the one-inch coil will be adequate for this set also. An adjustable spark gap, mounted on a separate base, would be best. The transmitting condenser and the helix may be the same as those described for Set No. 1. Greater pains must be taken with the insulation when a higher voltage is used. Such a set as this will send from ten to eighteen miles over land, or three times this distance over water.

After outgrowing these outfits, the experimenter will naturally wish to have a more powerful set, and for this purpose he will probably want a small transformer. Sets of that type are described in the following section.

CHAPTER III

TRANSMITTING APPARATUS: PROFESSIONAL OR HIGH-POWER STATIONS

In large stations where high power is used, the apparatus differs from that used in smaller ones less in character than in size and capability of standing increased current. A station containing a transformer of from one-quarter to five kilowatt capacity will use the following apparatus:

Alternating Current (or Pulsating Direct)
Telegraph Key
Transformer
Spark Gap
Condenser
Helix, or better, an Oscillation Transformer

The Power is usually an electric light current of either 110 or 220 volts, and preferably alternating. The alternating current is necessary for running a transformer to its best advantage. If only direct current, however, can be obtained, a somewhat similar effect may be produced by using a chemical or mechanical interrupter with the direct current.

The Electrolytic and the Mechanical Interrupter produce the same effect upon the direct current and give an effect approximating the alternations of the alternating current, which is what we need. An

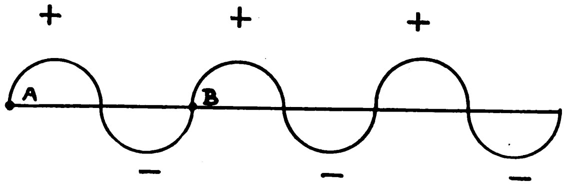


FIG. 10
ALTERNATING CURRENT

alternating current (see Fig. 10) makes complete cycles, passing from negative to positive, back again to negative, and then beginning a second revolution. The changes of polarity of this alternating current may be represented by the curve shown in Fig. 10, a

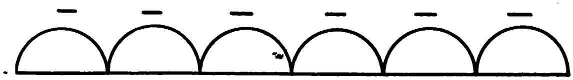


FIG. 11
PULSATING CURRENT

complete cycle being included between (A) and (B). A pulsating direct current, produced by means of an interrupter vibrates between the zero point and either negative or positive pole, but it does not change its

direction or polarity. Such a current may be represented by the curve shown in Fig. 11. There are thus no cycles, but the vibrations or pulsations have much the same effect upon a transformer as the alternations of the alternating current. *An Electrolytic or Chemical Interrupter* produces pulsations of the direct current in this manner: The positive lead goes to the anode in a glass jar containing a mixture of approximately

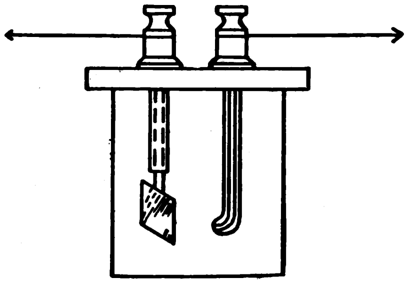


FIG. 12

nine parts water to one of sulphuric acid. When a current passes through this, bubbles are formed at the anode, and these discharging, the current from the large kathode or negative plate rushes to fill up the space and thus completes the circuit. This is done at very rapid intervals. A battery current of fifty volts is necessary to start the operation.

Mechanical Interrupters are of many types, but of nearly the same effectiveness. It is much better to buy a good instrument than to attempt to make one.

It should be of high pitch, and as simple in construction as possible. An excellent interrupter is shown in the diagram, Fig. 13. Its principle is that of the electric buzzer. It consists of a vibrating steel spring suspended tightly between two points. On one side of the spring is a magnet, and just above is a heavy platinum contact. The current, passing through the magnet, pulls down the spring and thus breaks the

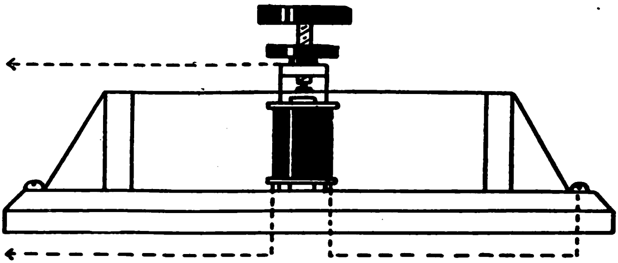


FIG. 13

MECHANICAL INTERRUPTER

circuit. At once the spring jumps back again to the contact and starts the current again. These interruptions are at a very rapid rate and at a high pitch, which may be varied by adjusting the spring. The pitch will also give a pure tone, such as is easily read at the receiving end.

The Key may be any one of the more substantial makes of commercial telegraph keys, provided there are heavy platinum contacts. Special wireless keys

suitable for use with transformers of from ¼ to 2 kilowatts are manufactured, and there are larger ones for heavier currents. The contacts may be of platinum, iridium, or silver, a compound of platinum and iridium making the best ones. A key for use with a ¼ to 2 kw. transformer should have contacts of about no. 10 wire. All keys used in high-power stations should have a one microfarad condenser strapped (or shunted)

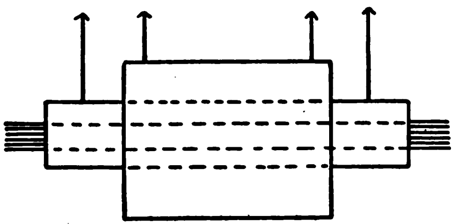
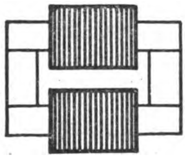


FIG. 14
OPEN CORE TRANSFORMER

across the contact points to prevent an arc from forming or the key from sticking.

The Transformer, like the spark coil, steps up the voltage of the current in order to charge the aerial. Indeed the spark coil is one form of a transformer, the so-called "open-core" type. In transmitting, both the open and closed core types may be used, but it is impossible to use the latter with pulsating direct current. The open-core type is preferable up to 5 kw. The closed-core type is less efficient, although

many prefer it even in the smaller sizes. It has the advantage that its size and output may be more closely computed. The difference between the two types



CLOSED CORE TRANSFORMER
FIG. 15

may be understood from the accompanying diagrams. Manufacturers have divided the closed-core types into the O type and the E type according to the shape of the core. The E type is perhaps slightly the more

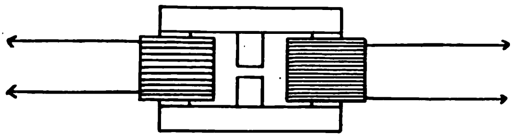


FIG. 16
CLOSED CORE TRANSFORMER
TYPE E

efficient, but both are good; and they are less expensive than the open or induction coil type.

The transformer for wireless work should have a secondary potential of from 15,000 to 30,000 volts.

The core of the closed-core transformer should be built of soft iron (laminations), matched together closely. Insulation should consist either of empire cloth or paper (the difference is slight) which is treated with a preparation containing linseed oil. Transformers are wound both for 110 and 220 volts, 60 or 120 cycles

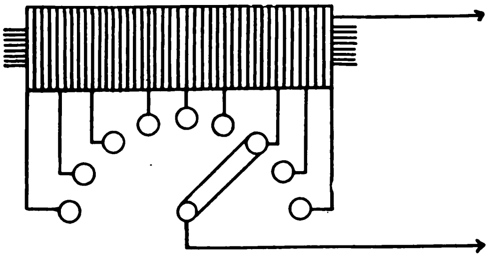


FIG. 17
REACTANCE REGULATOR

per second. Some commercial forms are so built that no impedence coil or rheostat, such as is usual, is necessary.

An impedence coil and a rheostat answer the same purpose in cutting down the primary current of the transformer, but in different ways. *An impedence coil* (usually called a Reactance Regulator) may be used only to cut down an alternating current. Fig. 17 will show this. A core of soft iron wire has wound on it several layers of single covered copper wire. An alternating current, passing through the coil, mag-

netizes the core. When the current is flowing in one direction, the poles of the core become north and south, respectively. The change of direction of the current then reverses this polarity and tends to retard the flow by *bucking* it. This lagging or *bucking* offers a resistance or impedence to the current. If, then, this coil is tapped at intervals, and the leads are connected

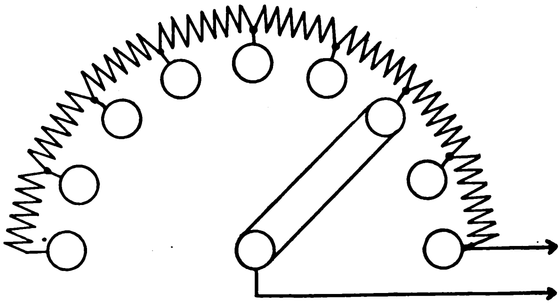


FIG. 18
RHEOSTAT

to a many-pointed switch, we may regulate the amount of reactance effect upon the current.

The principle of the *rheostat* is simpler. A wire of lower conductivity is placed in the circuit with points of adjustment, which determine the amount of resistance to be added to the circuit. This resistance wire is often German silver or iron.

A *bank of lamps* placed in the circuit has the same

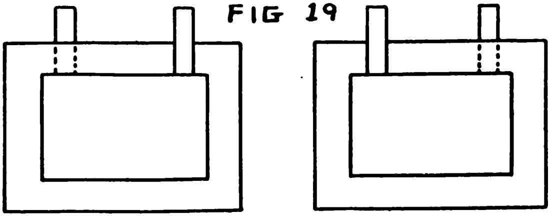
effect, and because much cheaper, is often used for the purpose. (See below, Fig. 53.)

The Spark Gap in high-power stations is different from that used in the smaller stations only in having larger sparking contacts, in its capability of standing increased current, and in its fineness of adjustment. Nickel-steel is generally used for the points, although silver is much better. When using over ½ kw., radiators on the handles of the sparking points will be found advantageous, and in fact almost necessary in order to keep the hot contacts cool, and thus to prevent the formation of an arc between them. A highly insulated base and handles are necessary to prevent damage to the operator from leakage of the current. With very high-power sets, several sparking points should be placed on the gap. This is the Multiple Spark Gap. In connection with it, a blow-pipe or fan is necessary to dissipate the gases formed and to cool the contact points, since if hot, these will allow the formation of an arc between the gaps. In sets of 2 kw. or more, the spark gaps should be encased in a box to prevent damage to the operator's eyes from the ultra-violet rays, and to his ears from the deafening noise. A glass front on the box may be used, since glass is impervious to the ultra-violet rays.

The Condenser, in high-power sets, should embody the same principles as that previously described. A glass-plate condenser is advisable by all means. Good flawless glass should be used. Plates should be of the

left and right design, since this ensures an even capacity per plate; for there are two sheets of tinfoil between each one. The plates should be arranged in units so that faulty ones may be removed without destroying the whole condenser. It is well to have the plates cast in some insulating material such as beeswax or rosin; or to immerse them in castor oil, which is one

FIG 19



RIGHT LEFT

CONDENSER PLATES

of the best dielectrics known. With care in these respects, the condenser will be satisfactory.

The Helix for this set of instruments should be made of heavy strip copper or large copper tubing and should be mounted on hard rubber. There should be two stationary and two or three variable contacts.

Oscillation Transformer. Better than a helix, however, and answering the same purpose, is an Oscillation Transformer, which gives not only more radiation, but more sharply tuned radiation. This instrument is an additional transformer, giving greater sharp-

ness of tuning to the station than is possible with a helix. Instead of the helix, we have now the primary of the oscillation transformer, which inductively passes on the oscillations received from the transmitting transformer to the secondary of the oscillation transformer. Through this process of induction, if the value of coupling, *i.e.*, the distance between the

HELIX

two coils, of the oscillation transformer is right, pure trains of waves are given off the aerial. The advantage of giving off sharply tuned or pure trains of waves from the transmitting station is that they may be picked up with less interference at the receiving end. These pure trains of waves (see Fig. 20) are formed by attracting to the same apex the apices of the weaker trains of waves, which would

otherwise form so-called *humps* in the wave (see Fig. 21). When there are humps there may be several tuning points, at the crests of each subordinate wave.

An oscillation transformer may be built to advantage by the operator. Both primary and secondary

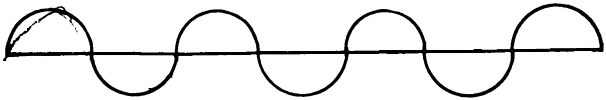


FIG. 20

should be of soft drawn copper ribbon or tubing wound on hard rubber or some other material of as high insulating or dielectric strength. There should be one stationary and one variable contact on both primary and secondary.

With apparatus like that here described, and with

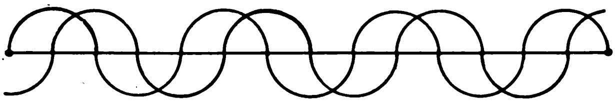


FIG. 21

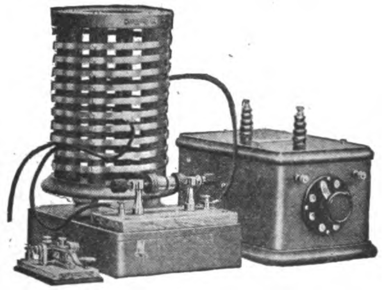
suitable aerial and ground connections, stations may be fitted up from ¼ to 15 kw. capacity. We shall add detailed lists of the instruments necessary for a few sizes of transformers.

Transmitting Set No. 3. ¼ Kilowatt. The 110-volt alternating current is all that should be used, although

the 220-volt current may be used with specially built apparatus. If *direct current* only can be obtained, an interrupter must be added.

The Key should be of a special wireless type with heavy contacts, and with a 1-mf. condenser connected across them.

The Transformer may be of either the open or closed core type. With direct current, the open-core type



COMPLETE SET

must be used with interrupter, the closed-core type giving little or no efficiency under the circumstances.

The Spark Gap should have contact surfaces of silver, of the design shown in Fig. 9.

The Condenser should have twelve or eighteen glass plates 8 x 10 inches.

The Helix may be of the general type described above, or, if desired, an *Oscillation Transformer* may be used.

Transmitting Set No. 4. ½ Kilowatt. The same *power*

requirements as in Transmitting Set No. 3. *The Key* should be similar to that in Set No. 3. There should be a transformer of ½-kw. capacity, of either the open or closed core type. *The Spark Gap*, with silver contacts ¾ inch in diameter, should have radiators on both arms. *The Condenser* should be of ¼-inch glass and should consist of from twelve to eighteen sheets of 10 x 10 glass, the insulating margins around the tinfoil being about 1½ inches. *The Helix* should have two or three variable contacts, of the same type as in Set No. 3. An *Oscillation Transformer* would be advisable.

Transmitting Set No. 5. 1 Kilowatt. The same *power* requirements as in Set No. 3. *The Key* should have very heavy silver contacts, of special 1-kw. design. *The Transformer* of 1-kw. capacity, of either open or closed core type. *The Spark-Gap* contacts should be one inch in diameter, and with radiating surfaces. *The Gap* should be of the enclosed type, in order to muffle the noise and to keep the injurious ultra-violet rays out of the eyes. *The Condenser* as in Set No. 4. A *Helix* may be used, but a *1-kw. Oscillation Transformer* is strongly advised.

Transmitting Set No. 6. 2 Kilowatt. Power requirements as in Set No. 3. A *Key* with heavy ½-inch silver contacts. A *2-kw. Transformer* of either open or closed core type. An *enclosed Spark Gap* with silver sparking surfaces 1¼ or 1⅜ inches in diameter. A *Condenser* constructed in units so that

it may be connected in series multiple to relieve the dielectric (or insulating) strain. There should be thirty to forty sheets of $\frac{1}{4}$-inch glass, 10″ x 10″ in size, and immersed in castor oil. A *Helix* may be used, but is not recommended. *The 2-kw. Oscillation Transformer* is necessary to stand the current.

Transmitting Set No. 7. 5 Kilowatt. Power requirements as in Set No. 3. A special *Key* with $\frac{3}{4}$-inch silver contacts and a 2-mf. condenser. A *5-kw. Transformer*, preferably of the open-core type. An enclosed multiple *Spark Gap*, with blow-pipe or fan, is necessary. Five or six sparking surfaces, $\frac{1}{2}$ inch in diameter will be sufficient. *The Condenser* must be in units, with twenty to forty plates of $\frac{1}{4}$-inch glass, 14″ x 14″, and with 2-inch margins, and immersed in castor oil. An *Oscillation Transformer* of special design is necessary.

CHAPTER IV

THE RECEIVING CIRCUIT

THE transmitting apparatus is always engaged in radiating waves from its aerial. These waves, starting from that aerial as a common centre, pass on in ever-widening circles, as do the ripples in water when a stone is dropped. All original activity is confined to this process of sending waves from the transmitter, and the journey of the waves in their circles is as far as the electrical current behind the transmitting apparatus is able to send them. But another process is necessary before wireless communication is established. Not only must waves be sent out, but there must be a way of determining what signals they bear. This is done by stationing another set of instruments somewhere in the circular course of the waves, and this second set of instruments must be able to reveal to the operator the meaning of the signals. This second set is called the *receiving station.* It must be placed within the radius of the waves sent out from the transmitter, but the nearer it is to the sending instruments, the louder and clearer will the signals be received.

Again an aerial is used, but instead of acting as an outlet for waves generated by the instruments below, the receiving aerial or antenna (just as the antenna or feeler of the crab informs him what is passing) conveys to the operator through the receiving instruments news of what is passing. Wireless messages cannot at present carry any secrets of importance, for every aerial within the sending range of the transmitter will carry the message to the operator below. The electrical current necessary to radiate wireless messages from the transmitting aerial is very great, because the waves must radiate in every direction, and cannot be confined to one path as the wire of a wire telegraph confines its current. At the same time, the power received at the receiving station will be infinitesimal, for the very same reason of this scattering of energy. Thus it is necessary to have the most sensitive of receiving instruments in order to detect the waves and make their signals known to us.

The two absolutely necessary parts of the receiving circuit are an aerial and a ground connection. The aerial receives or *picks up* the wave signals by vibrating with the frequency of the waves. Thus a surging effect is set up in the aerial between air and ground. But however true this may be, we must add other instruments before we shall be able to discover them. First of these is the *detector*, which, as its name implies, is used to detect the presence of electric vibrations in the aerial circuit. These vibrations or oscillations

may be detected in various ways, and the several different detectors work on quite different principles. As the mineral forms are most common, and are probably the most efficient, it will be enough in this

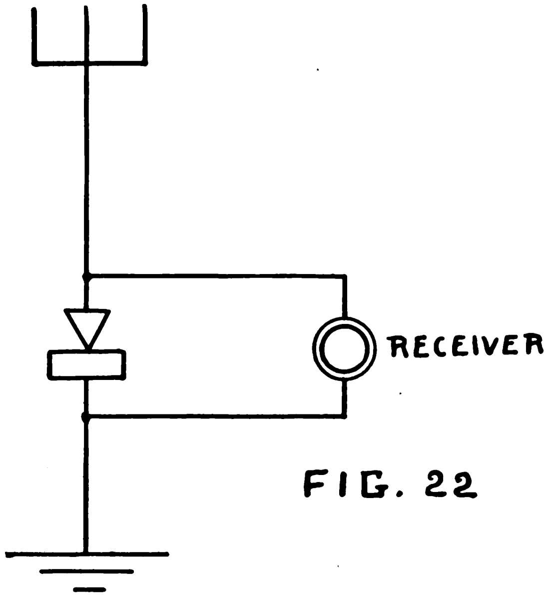


FIG. 22

place to take one of these, the *silicon detector*. When, in a detector attached to an aerial circuit through which oscillations are surging, a point of brass rests against a flat surface of silicon, it will allow the current to pass more readily in one direction than in the other.

Thus instead of the alternating current set up by the electric waves, we have a rectified direct current passing through the telephone receivers connected

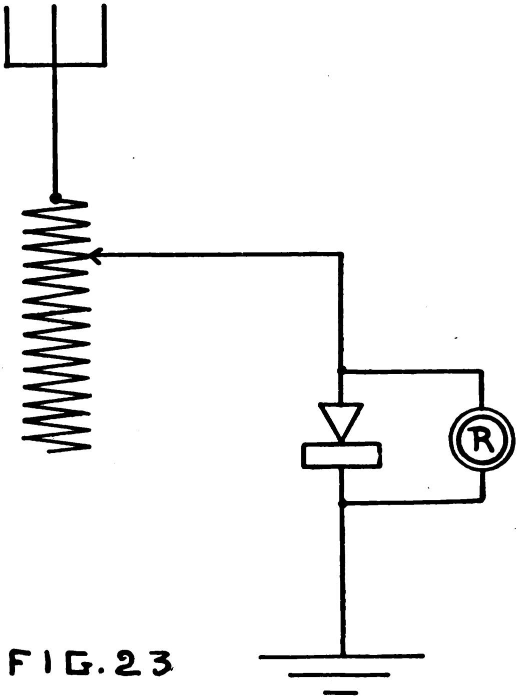


FIG. 23

across the detector. By this means we hear the intermittent splashes of the sending key, and by means of a recognized code we are able to form words from them.

Thus is formed the simplest receiving circuit (see Fig. 22) which will be capable of receiving signals of a wave length comparable with our aerial. But if

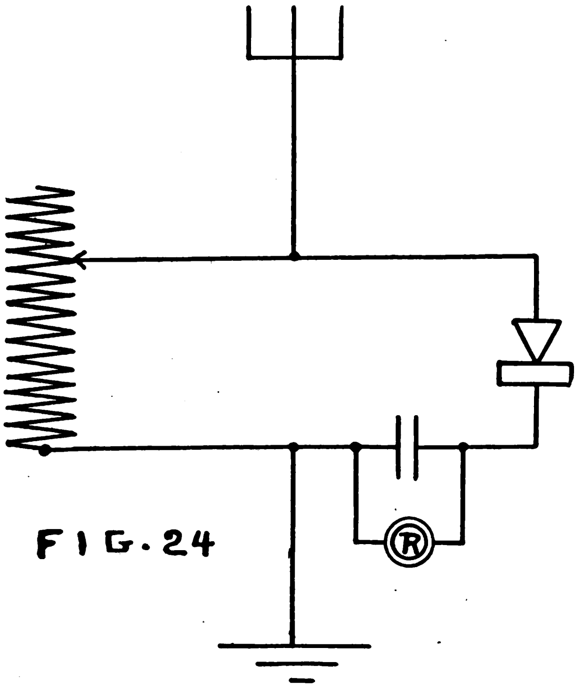


FIG. 24

waves of greater length are passing, they cannot be picked up by our simple aerial. We therefore add to its (the aerial's) inductance — that is, to its time of

vibration — by placing a coil of wire in the aerial circuit. A variable contact on this "tuning" coil allows

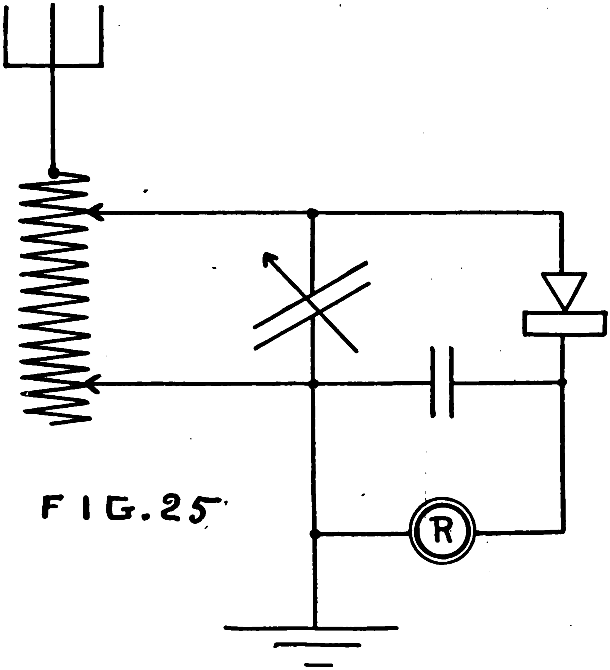


FIG. 25

us to lengthen our oscillatory circuit in accordance with varying wave lengths.

The first purpose of the receiving instruments is to make it possible for the aerial to vibrate in harmony with the waves it picks up. The tuning coil is a dis-

tinct addition in increasing this capability of tuning, but another instrument, the condenser, adds the second improvement in this respect. The effect of the condenser is similar to that of the coil—it adds capacity to the circuit and makes it possible to balance

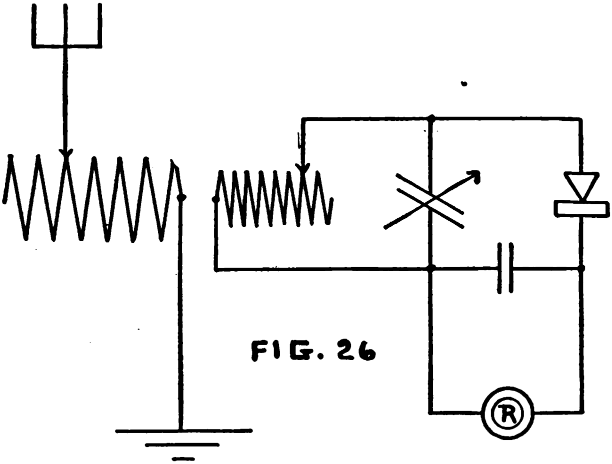


FIG. 26

the circuit with the frequency of an incoming wave. Fig. 24 shows the addition of a condenser of fixed capacity to the circuit, and Fig. 25 shows the further addition of a variable condenser. This latter secures the very finest adjustment for balancing the circuit.

The next improvement in the receiving circuit is to remove the detector circuit entirely from the aerial. This is done by using an oscillation transformer instead

of a tuning coil. We have now two entirely separate circuits, both of which may be equally balanced to any frequency, and which are connected only by induction (*inductively coupled*, we say). The primary of the oscillation transformer is in the aerial circuit, where a complete oscillatory circuit is made. We can, then, vary the primary in the aerial circuit; vary the secondary in the detector circuit, balancing it with the primary; and we can vary the coupling between the two. Then, when our aerial is tuned with the incoming wave, and the secondary circuit is balanced with the primary, this variation of coupling enables us to cut down interference from stations we do not want to receive, and at the same time to bring in more clearly those stations we want.

If the coil in any of these circuits is inadequate to receive waves from any desired station, another coil may be placed in the aerial circuit to add greater inductance. Such a coil is called a *loading coil*, and may be used as well with an oscillation transformer as with an ordinary tuning coil.

CHAPTER V.

RECEIVING APPARATUS

The receiving station is usually the first one experimented upon, and might more properly precede the transmitting station in our description. It has, however, been thought best to keep to the logical order.

The instruments necessary for a receiving set are as follows:

Detector	Fixed Condenser
Telephone Receivers	Variable Condenser
Tuning Coil	Oscillation Transformer

The Detector is the most essential part of the receiving apparatus, and its purpose is most vital for receiving wireless signals. The waves received from transmitting stations are picked up by the receiving aerial. As a result, an alternating current of very high frequency is set up and surges in the aerial and the receiving circuit. The detector causes this exceedingly feeble current to become perceptible to our ears, by means of very sensitive telephone receivers. The methods are based on different theories according to the type

of detector used, the earliest form, the coherer, depending upon a quite different principle from that of the recent mineral detectors. Some forms once used have been discarded, while new and more sensitive detectors are still being discovered. We shall mention only a few of the most important types, giving them in their historical order, which has proved to be the order of their respective values.

The Coherer is mentioned only because it was the earliest form used. This is constructed of a small glass tube with two highly conducting electrodes of

FIG. 27 COHERER

silver. Between these the space is partially filled by a mixture of nickel and silver filings. Large filings, which have a low resistance, are used with relays of low resistance, while finer filings, lying in the tube with a high resistance, are used with relays of high resistance. The filings have normally high resistance. When a signal is received from a transmitting station on an aerial or oscillator, an electric wave conducted to these filings breaks down the resistance caused by the oxide existing on their surface, causes them to cohere and thus lowers the resistance. This lowered resistance and the consequent more perfect path for the current can be easily detected by a relay which is in the circuit

with a battery. This relay in turn may be coupled to any electrical device, for instance the ringing a bell, lighting a lamp, directing a torpedo boat, etc. The coherer of this principle is no longer used, other and more sensitive detectors having taken its place.

The Carbon Detector was a transient device, used but a short time for wireless work. It would be hard to find one to-day, although they became prominent

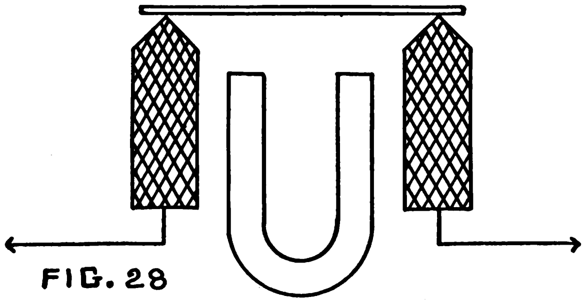


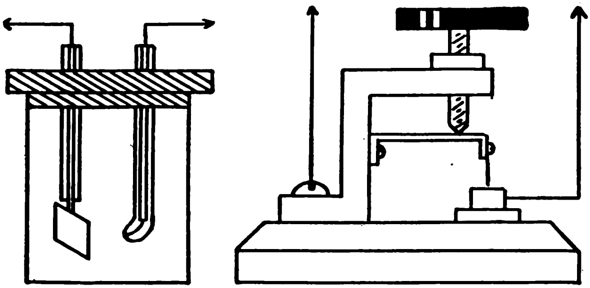
FIG. 28

CARBON DETECTOR

only a few years ago. It was an improvement over the coherer, being somewhat more sensitive and reliable. It is often called a microphone detector. It consists merely of two blocks of carbon, upon which rests a steel needle. The pressure of the needle upon the carbon is varied by the pull of the permanent magnet underneath. Adjustment depends upon having an imperfect contact between the needle and the carbon. The effect of electric waves upon this detec-

tor is to vary the resistance between carbon and needle and to indicate this in a telephone receiver, connected in the circuit together with a battery.

The Electrolytic Detector works on an entirely different principle, and was a great improvement over the two earlier forms. It is still largely used. This detector works on a rectifying principle. It may be

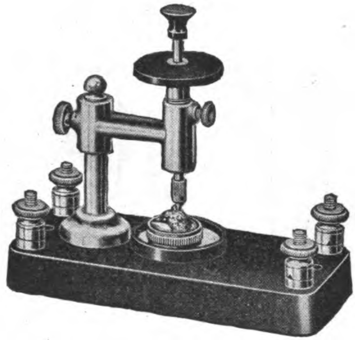


SEALED POINT BARE POINT

FIG. 29

constructed in two ways, the sealed point and the bare point. The bare point has a fine platinum wire for an anode which rests in a cup of dilute nitric acid. In the sealed point type the fine platinum wire is sealed in a glass tube with its lower end flush with the tube's lower or sealed end. Both forms work on the same theory, which is shortly this: A fine platinum wire just touches the surface of the liquid, and when a slight battery current passes through the circuit,

bubbles are formed at the wire. If the adjustment is just right, these bubbles will continually form, thus making a gaseous insulation about the wire. Now, if there is an aerial and ground connection, a wave picked up by the former becomes a feeble alternating current which breaks down these bubbles. When the circuit between acid and point is thus made, the current



SILICON DETECTOR

passes through and may be detected in the telephone receivers connected in the circuit. At the same time, the acid rushing to the temporary conducting point starts up a direct current which is perceptible in the receivers. This is a rectifying effect.

An electrolytic detector is more easily made than purchased, and is quite as likely to be satisfactory. For the sealed point no adjustments are necessary, but the bare-point type requires very fine adjustments

indeed; for unless the wire can be placed exactly, no effect is produced. It is essential that a battery and potentiometer be used in circuit with either form.

The Solid Rectifiers, sometimes incorrectly called Crystal Detectors, may depend upon any one of several different minerals which have been proved by experiment to have rectifying influence upon alternating currents of high frequency. It is thought by many that this is aided by some thermo-effect. The silicon

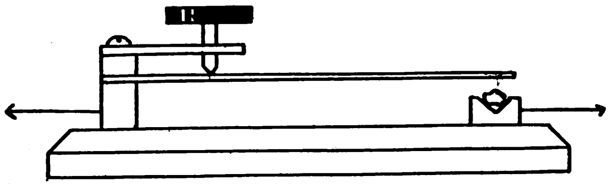


FIG. 30

detector was the first of this type to be universally considered successful. It is still one of the most important and popular ones. Its principle, as has already been stated, is that of a rectifier. No battery is necessary, although a battery and potentiometer help matters along to some extent. The silicon detector consists of a flat surface of highly polished silicon (the flawless kind is best), upon which rests a brass point. A circular or spherical piece of brass resting on the flat surface of silicon makes the finest contact of all. A good experimental form is to allow a sharp

fragment of silicon to rest upon a flat surface of highly polished brass. The detector stand should be so arranged that any part of the silicon surface may be

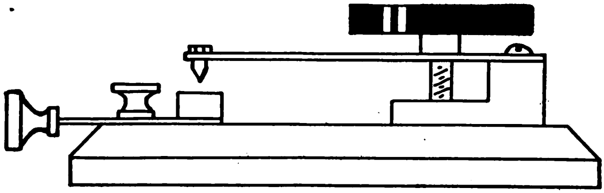


FIG. 31

used. Its simplicity is one chief advantage in favor of the silicon detector. No special care is necessary, and its adjustment is very easily made. The adjustment is, however, easily broken when used with a

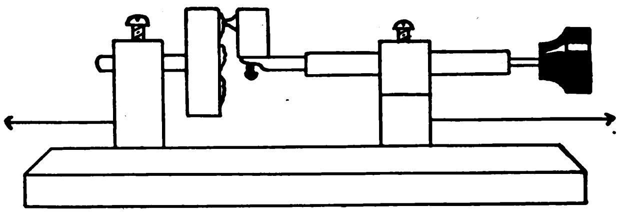
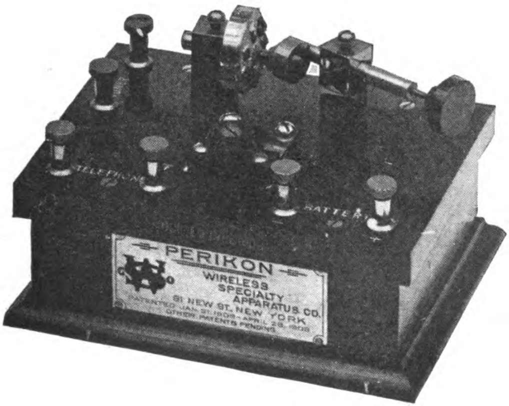


FIG. 32

transmitting set. Nevertheless the silicon detector is advised for all general purposes.

A very good solid rectifier or mineral detector is the *Pyron Detector*, which also works on a rectifying

principle. The adjustment is harder to obtain than with silicon, but once found is more stable, remaining for months at a time in a very sensitive condition. It works with a brass point against the oval fractures of the mineral iron pyrites, sometimes called "fool's gold." A pyron detector stand is somewhat different

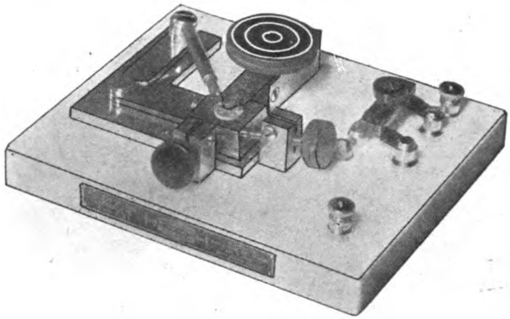


PERIKON DETECTOR

from that for silicon, the cup containing the mineral being held more rigidly by a pivot and screw, so that adjustment, once found, may be retained.

The Perikon Detector is now generally held one of the best. It gives far more sensitive and quick adjustment than does silicon, and retains it better. It works on a rectifying principle. The perikon detector

consists of a vertical cup into which are fused five or more fragments of zincite, or zinc oxide. Another cup containing a fragment of chalcopyrite, or better still of bornite, is fused into a cup held at the end of a rotating rod which may be adjusted, by means of an inside spring, to any desired pressure against the zincite fragments. The zincite best for this work occurs in



PERIKON–ELEKTRA DETECTOR

layers, and the cross-section of these layers forms the best surface for adjustment. A pressure of from ½ to 2 ounces is necessary to secure the best results.

A very recent form is the new *Perikon-Elektra Detector*, which also acts on the rectifying principle. This detector uses a micrometer adjustment, and its stability is remarkable, while it is half as sensitive again as is perikon. This is Mr. G. W. Pickard's latest achievement in detectors.

There are numerous other forms of detectors, but those already described are the best and most sensitive. We will, however, mention two or three others in pass-

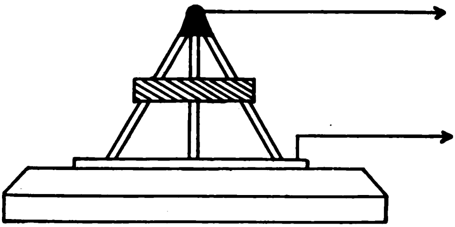


FIG. 33

ing. *The Tripod Detector* (Fig. 33) consists of three needles resting on an aluminum plate, and works on the principle of partial contact. *The Carborundum Detector* is a crystal form, somewhat less sensitive

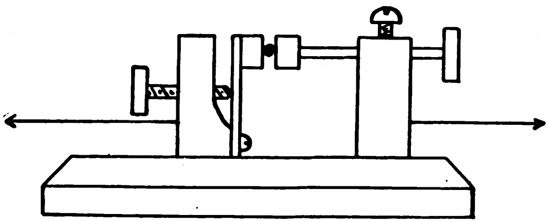


FIG. 34

than silicon (Fig. 34). It consists of a piece of carborundum resting between two carbon blocks.

The Magnetic Detector works on the principle of

diminution of hysteresis; that is, on the principle of the sudden drop in magnetism caused by a shock to a piece of shakily magnetized soft iron, and its consequent effect in producing a current in a near-by coil connected to a telephone receiver.

A battery is often used with the detector and is

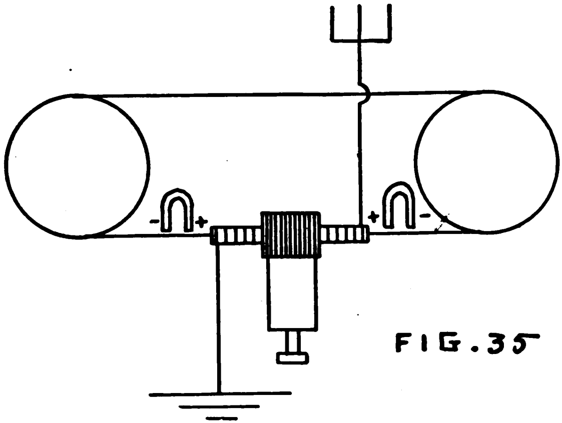


FIG. 35

necessary for the proper results with a coherer, a carbon, a carborundum, and an electrolytic detector. It will also increase the efficiency and aid in the quick adjustment of the silicon, pyron, and perikon, but should not be used with the magnetic or perikon-elektra forms.

The choice of a detector depends largely on the kind of station constructed. For general experimental purposes, silicon is most adaptable. The electrolytic is

useful and very reliable, but inconvenient to handle. The patent rights on pyron, silicon, and perikon detectors make them more expensive, however much they are superior to other forms.

The potentiometer is a necessity when using an

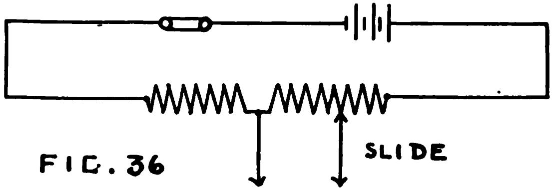


FIG. 36

electrolytic, carborundum, carbon detector, or coherer, and an advantage even with a mineral detector. Its purpose is to vary the voltage, and thus to fix a definite amount of potential necessary for the best advantage

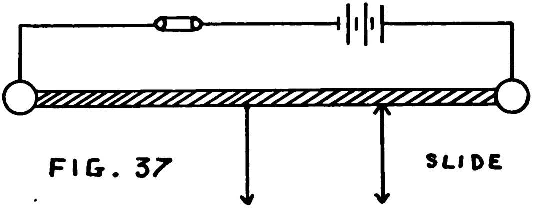


FIG. 37

of the detector used. The potentiometer may consist either of German silver wire or a stick of high-resistance graphite connected across a local battery. A slide is necessary, and if desired, the potentiometer may be tapped in the middle and a lead carried

into the circuit. The advantage of this last is that the direction of the battery may be reversed without a pole-changing switch.

The potentiometer used with the silicon or other rectifying mineral forms may be of less resistance than that used, for instance, with the electrolytic detector. With the electrolytic, about 300 ohms resistance and three old dry cells are needed, requiring about 140

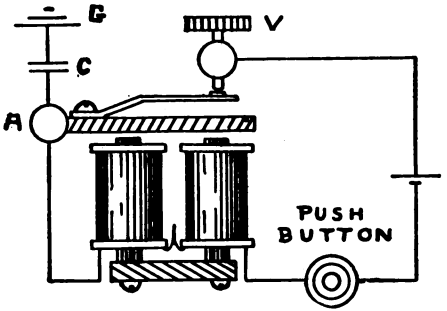
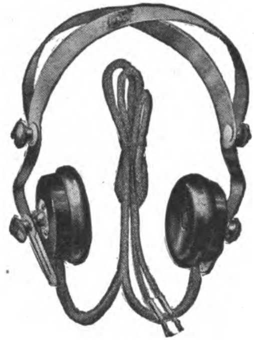


FIG. 38

feet of no. 32 German silver wire or 90 feet of no. 36. With the silicon and other detectors, only one cell and about 150 ohms should be used.

A *Testing Buzzer* is of great advantage with any detector; it generates feeble electro-magnetic waves which affect the detector and thus enables the operator to obtain the most sensitive adjustment. A small buzzer is best, and a wooden push button affords the necessary insulation. Only one cell and a small con-

denser are needed. The diagram (Fig. 38) shows the connection. The vibrator point (V) or better the point (A) must be connected through the condenser (C) to the ground (G). The condenser should be about six square inches of tinfoil on each side of a sheet of waxed paper, with some variation of size, according to the strength of signals desired. It will be observed, however, that weak signals are usually best, and for these a small condenser is needed.



HEAD SET

Telephone Receivers are necessary with all of the more recent types of detectors, in order to make perceptible minute fluctuations of current. For wireless work receivers of high resistance are advisable, and up to a certain point, the higher this resistance the more sensitive the receivers are to feeble currents. Not that a great resistance makes the receivers sensitive,

but that a very large number of turns of fine wire around the magnet influences the magnetism of the core on receiving a much feebler current from the detector. Therefore very fine copper wire, a large number of turns, and their nearness to the core are the essential qualities of a wireless receiver. The classification of receivers according to resistance is merely a method of showing the number of turns and the fineness of the wire used; *i.e.*, the sensitiveness. All this is true up to a certain point only. The fineness of wire and the great number of turns used to wind receivers of over 3000 ohms does not add to their sensitiveness, the current dispersed over so much wire being incapable of imparting as much strength of magnetism to the core as in the case of receivers of from 2000 to 3000 ohms resistance.

As will be seen from what has gone before, receivers should be wound with single covered copper wire. Enamelled copper wire may be used for this purpose. A very recent receiver wound with this wire held inside a tiny spark gap in order to prevent burning off the insulation. Some unscrupulous dealers have partly wound the magnets with German silver wire in order to increase the resistance of the receiver, and thus to obtain a high price for it. It will be understood, however, by this time, that such a receiver is no better if as good as one wound with the same number of feet of copper wire, with a resistance usually one-thirteenth that quoted on the fraudulent receiver (the resistance

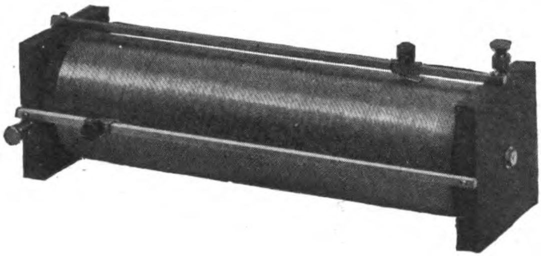
of German silver being about thirteen times as great as copper).

The receiver cases may be of hard rubber or aluminum. A composition material is most frequently used, and while very much cheaper is more brittle than hard rubber. For wireless work, a receiver must be of the bi-polar type, the single-pole type giving very unsatisfactory results. The diaphragm may be of ordinary thickness, especially in a receiver of a new design which has a small screw to adjust the distance between diaphragm and magnets. Thin gold-plated diaphragms are sometimes used in order to secure sharp signals, while thicker diaphragms will give signals of duller tone. Dull signals can be read in spite of static interference, which would make sharper signals unreadable. The gold-plate is to prevent rust, but lacquer serves the same purpose.

The head band for the receivers may be of nickelled brass or German silver, and may be leather covered for insulation. The convenience of the wearer will determine its shape. Sometimes pure gum rubber tubing is put over the head band, both for its insulation, and for the comfort to the operator. Rubber ear cushions over the receivers, which are often used, are not advisable. They increase the distance of the receiver from the ear and may weaken all very faint signals.

The Tuning Coil is a device by means of which the aerial circuit is increased (or tuned) so as to receive

incoming waves, whatever their wave length (train frequency). The tuning coil is arranged with one or more variable contacts so that this increase in the aerial circuit may be adapted to the length of any waves we desire to receive. The tuning coil is connected with the aerial circuit so as to synchronize (or time) the vibrations of the aerial with the wave length or train frequency of the transmitting station. This increase to the aerial circuit does not depend



TUNING COIL

entirely upon the length of wire contained in the coil, but upon the amount of coil inductance in the aerial circuit or inductively coupled to it.

A tuning coil should be wound of soft drawn bare copper wire, approximately no. 22, on a core of unshrinkable highly insulating material, such as hard rubber or cardboard seasoned or soaked in shellac. Fibre is sometimes used, but is not to be depended upon. Bare copper wire is best, although single covered copper wire may be used if paths are cut

through the insulation for the slides. Enamelled wire is not good for a tuning coil; not only does it refuse to maintain its close tension around the core and become loose, but the enamel acts as a sort of condenser between turns because of its extreme thinness, and makes the tuning broader or less definitely sharp than is necessary. The wire of the coil must be well insulated, by winding in a thread cut in hard rubber, by spacing it on a screw-cutting lathe on cardboard, or by winding it with a thread between each turn. Such a coil should be from three to four inches in diameter and twelve or eight inches long. There is no advantage in having a larger coil, as the wave lengths of practically all stations come within this range. If a greater range of tuning is desired, which will be rare unless for the extremely long waves used by the trans-atlantic stations, it is better to have a *loading coil* which may occasionally be switched into the circuit, and which will not permanently burden it.

One, two, or three variable contacts (slides, sliders) are used on tuning coils. Although the three-slide form is employed for its greater selectivity and to produce a loose-coupling effect, the one and two slide forms are most popular for general use. The slides should have a phosphor bronze spring, preferably with a rolling contact, and a well insulated handle.

A *Loading Coil* is a supplementary coil used to give a greater inductance to the circuit, and thus to give it a greater range of resonance, and to enable it to

receive longer waves or those of much lower frequency. In form it is merely a single-slide tuning coil.

The Condenser collects and holds electricity. Its conductors are very close together, and adjacent ones are charged with opposite kinds of electricity — one negatively and one positively. An alternating current passes readily through a condenser, because the charge keeps changing from negative to positive and back

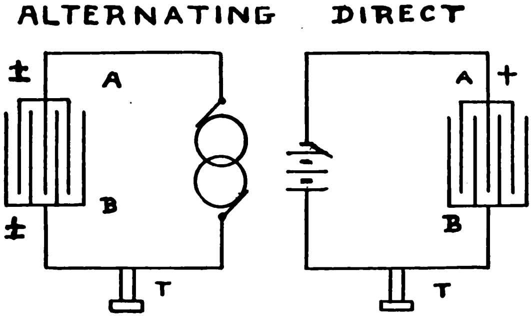


FIG. 39

again. A direct current, while it will give the same initial charge to the first plate, cannot pass through the condenser, since only the change of polarity will maintain the charge in the opposite plate. In other words, we have the two plates of a condenser (A and B), through which an alternating current is passing. When A receives a positive charge, it repels the positive charge from B and attracts the negative; thus B is negative. When A reverses and becomes negative,

B becomes positive for the same reason. The same process goes on; A, constantly changing, forces B to change, and the current continues. When a direct current is led to the condenser it charges A positively. B at once becomes negative and remains so. There is no change of direction in the current after the first connection, and therefore the charge remains fixed and no current can pass.

For wireless work, there are two kinds of condensers

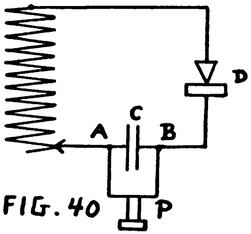


FIG. 40

— those which present a fixed value and those where the condenser value may be varied at the will of the operator. The former is called a *Fixed Condenser*, the latter a *Variable Condenser*.

A *Fixed Condenser* is used in order to balance one part of the circuit with the other. This is a part of the process of *tuning or bringing the circuit into resonance* with the transmitting station. Practically the principal use of a fixed condenser for receiving is to short-circuit (*shunt*) the telephone receivers. For instance, in the circuit shown in Fig. 40 the high frequency

current set up in the oscillatory circuit will more readily pass from A to B through the condenser (C) than through the receivers (P), since the latter offer a much higher resistance to it. When a detector rectifies the high frequency alternating current to a direct current, the condenser opposes the passage of this direct current, which therefore passes through the receivers and comes to our ears. A fixed condenser may also be used in the circuit to prevent short-

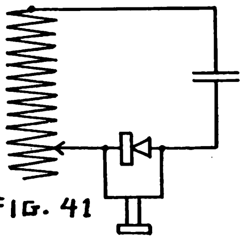


FIG. 41

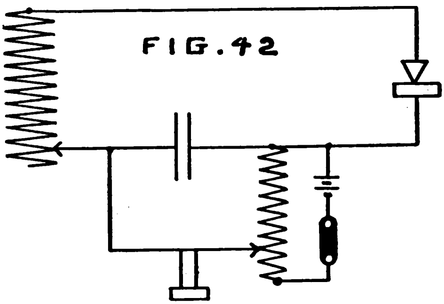
circuiting the detector, when the latter is connected across a coil. This latter connection is, however, of less advantage.

The capacity of a fixed condenser ranges between .002 and .005 microfarads (mf.). Those of large capacity should be used with telephone receivers of low resistance, of smaller capacity with receivers of higher resistance. This is because the larger wire used in the low resistance phone offers an easier passage to the current than the finer wire used in the higher resistance phone, and therefore the low resistance

phones need more condenser to balance the circuit than do those of higher resistance.

Where a potentiometer is used, it should be short-circuited by a fixed condenser and be placed with the phones (see Fig. 42).

The Variable Condenser is used to enable the operator to tune or bring the circuit into finer resonance than would otherwise be possible. If the point of sharp-

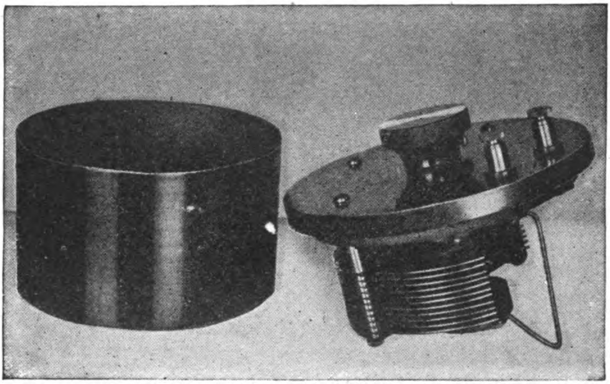


est tuning happens to come between the turns of the coil, and where it cannot be reached exactly by any of the slides, the variable condenser makes it possible for the operator to reach the exact point of sharpest tuning, and thus to obtain the most accurate results.

There are two very good kinds of variable condensers, the Rotary and the Slide Plate types. The Rotary type is the easiest one to manipulate and is the most convenient. If aluminum plates of large diameter, however, are used, there may be some sagging of the

metal, which will cause the plates to short-circuit. The Slide Plate type, while more troublesome to manipulate, has the advantage of greater stability, and its condenser values are more nearly proportionate to the adjustment.

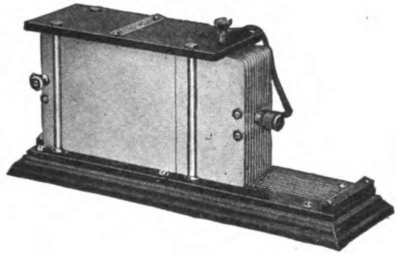
The plates may be of brass or aluminum, and of



ROTARY CONDENSER

stock sufficiently heavy to prevent sagging. For this reason brass is more durable. The clearance between the plates should be as little as possible. Many commercial variable condensers have a clearance of $\frac{1}{32}$ of an inch. Those with $\frac{1}{64}$ are better, but are rare. The highest capacity of a variable condenser should not be over .004 mf., .003 mf. being that most often necessary.

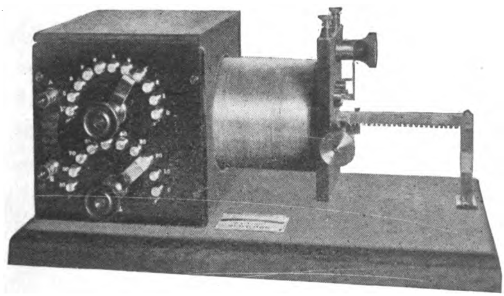
An *Oscillation Transformer* is added to a receiving set in order to obtain more selective tuning than the ordinary tuning coil will give. They may be easily



SLIDE PLATE CONDENSER

made and at small comparative expense. They are simple to operate, and generally increase the receiving range of a station.

The best oscillation transformers are wound on



OSCILLATION TRANSFORMER

threaded hard rubber, both primary and secondary. Next to hard rubber comes shellacked cardboard, on which the wire may be spaced on a screw-cutting lathe or wound with thread for insulation. In size the *primary* should be about four inches in diameter and four inches long. No. 22 bare copper wire should be used, twenty-four turns to the inch, about 100 turns in all. One slide with rolling contact on the primary is necessary. The clearance between pri-

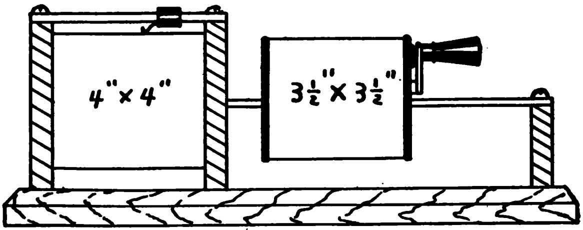


FIG. 43

mary and secondary should be as small as possible, not more than ¼ inch. The *secondary* should be about 3½ inches in diameter, and the winding about three inches long. Nos. 26 to 28 bare or single silk insulated wire should be used, about 200 turns in all. The secondary should slide in and out of the primary, and not rotate inside, since by drawing secondary away from primary we vary not only the magnetic of the two coils, but also the mass capacity between the two. In this way we may cut out static effects which

interfere with our receiving. With 200 turns on the secondary, taps should be taken out every twenty turns and brought to a many-point switch.

By the addition of a second oscillation transformer, using a circuit like that shown in Fig. 44, much finer tuning still will be possible, although the difficulty of tuning will at the same time be increased. This is called a *Weeding-out Circuit.* Indeed it is possible to add another oscillation transformer, to gain still

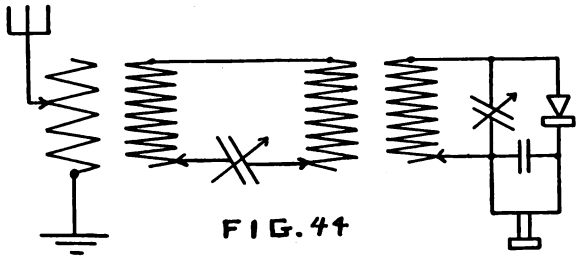


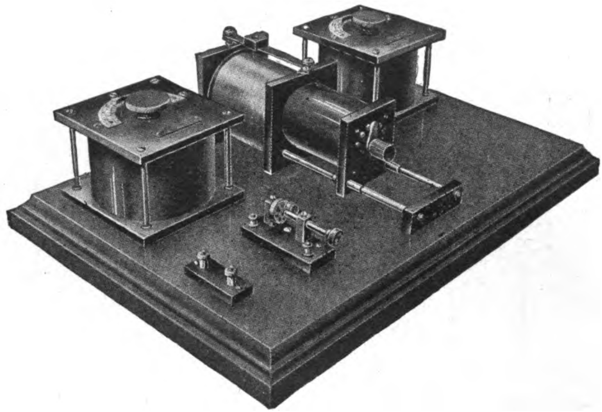
FIG. 44

finer tuning, and at the same time make tuning more difficult. Neither of these circuits will be used, however, except where the interference is very bad; and then only seldom, as there is a slight loss of energy as each one is added.

We have now mentioned all the usual instruments for receiving. Only a few out-of-the-way or merely experimental forms have been omitted, and those intentionally. We shall now give a selection of such sets of apparatus as are well fitted for use together,

and which will be adapted to certain receiving distances, at reasonable prices.

Receiving Set No. 1 with Single Slide Tuning Coil. Silicon Detector; one 80-ohm Receiver; Fixed Condenser (.004 mf.); Single Slide Tuning Coil, three inches in diameter and twelve inches long; Two-wire



COMPLETE RECEIVING SET

Aerial of no. 12 or 14 copper or aluminum wire, 50 feet long and 50 high, of the T or L type. For receiving distance, use table on page 170.

Receiving Set No. 2 with Double Slide Tuning Coil. Silicon or Electrolytic Detector and Potentiometer; one 1000-ohm Receiver with Single Headband; Fixed Condenser (.003 mf.); Double Slide Tuning Coil, same

dimensions as in Set No. 1; Aerial as in Set No. 1. For receiving distance, see tables.

Set No. 3 with Double Slide Tuning Coil. Silicon or Electrolytic Detector and Potentiometer; two 1000-ohm Receivers and Double Headband; Fixed Condenser; Double Slide Tuning Coil; Variable Condenser, Slide Plate type; Four-wire Aerial, 50 to 75 feet long and 60 feet high, of no. 14 copper, aluminum, or phosphor bronze wire, T, L, or Fan types. For receiving distance, see tables.

Set No. 4 with Three Slide Tuning Coil. Silicon or Perikon Detector; 2000-ohm Receivers, as in Set No. 3; Fixed Condenser as in Set No. 2; Three Slide Tuning Coil, same dimensions as in Set No. 1; Variable Condenser, either Slide Plate or Rotary type; Aerial as in Set No. 3. For receiving distance, see tables.

Set No. 4 with Oscillation Transformer. Perikon Detector; Potentiometer; two 1500-ohm Receivers and Headband; Fixed Condenser (.0025 mf.); Receiving Oscillation Transformer; two Variable Condensers (.003 mf. each). The receiving range of this set may be increased practically without limit, according to the type of aerial used. For aerial, see Chapter VI and diagrams on page 71.

CHAPTER VI

AERIALS AND GROUNDS: TYPES AND CONSTRUCTION

OF first-rate importance in constructing a wireless station is the choice of a type of aerial and a good ground connection for the apparatus. Ground connections are usually easy to obtain and cause little difficulty. Not so, however, with the aerial. We must select a type of aerial suitable for our surroundings, and we must decide upon the size necessary for the transmitting and receiving distances we wish to cover, and we must consider the mechanical difficulties of construction, the cheapest kind of wire suitable for the necessary spans, and the proper insulation of it.

Any aerial which can be used for transmitting makes a good receiving aerial. The converse of this is not always true, for not every good receiving aerial can also be used for transmitting. Therefore the wireless operator will always wish to construct a transmitting aerial, and those described in this chapter are of this kind and may be used indifferently for both purposes. This simply means that there must be a number of strands and that the extreme height of the aerial is somewhat less than its length.

The Straight-away and the *Loop* are terms used to indicate the method of connecting the aerial. In the straight-away form all the upper wires end dead on an insulator. These upper wires in the *loop form* are all connected together and divided into two sec-

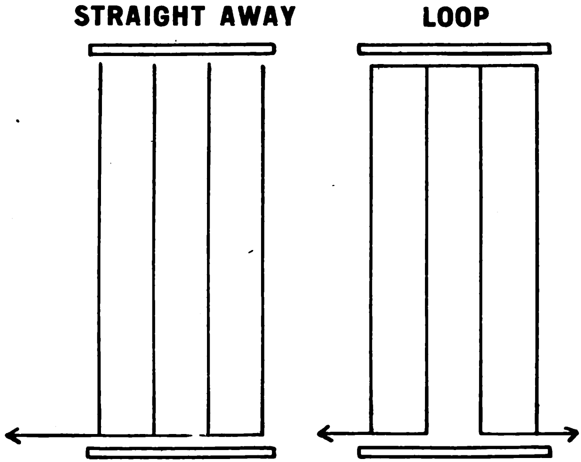


FIG. 45

tions at the bottom, as shown in Fig. 45. Aerials of almost any type may be erected in either form, but while the loop gives slightly better results on a short aerial, the straight-away is decidedly the more efficient in most cases.

There are about six types of good aerials, but the combinations of these are almost innumerable. Each

of the main types, however, is distinct; and it seems best to confine our attention to their principal features. In the order of similarity of construction these are

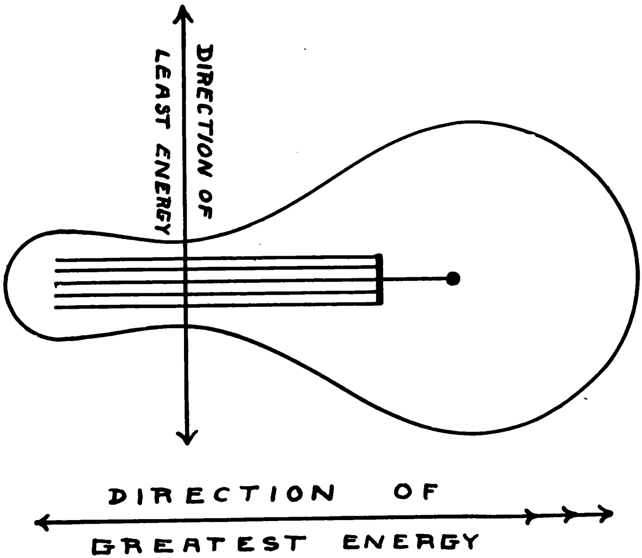


FIG. 46

the *T*, the *Vertical*, the *L*, the *V*, the *Fan*, and the *Umbrella* types.

Of all these the T is most nearly perfect and gives the best results. For one thing, the I aerial is not directional to any considerable extent, as is the L or the V type.

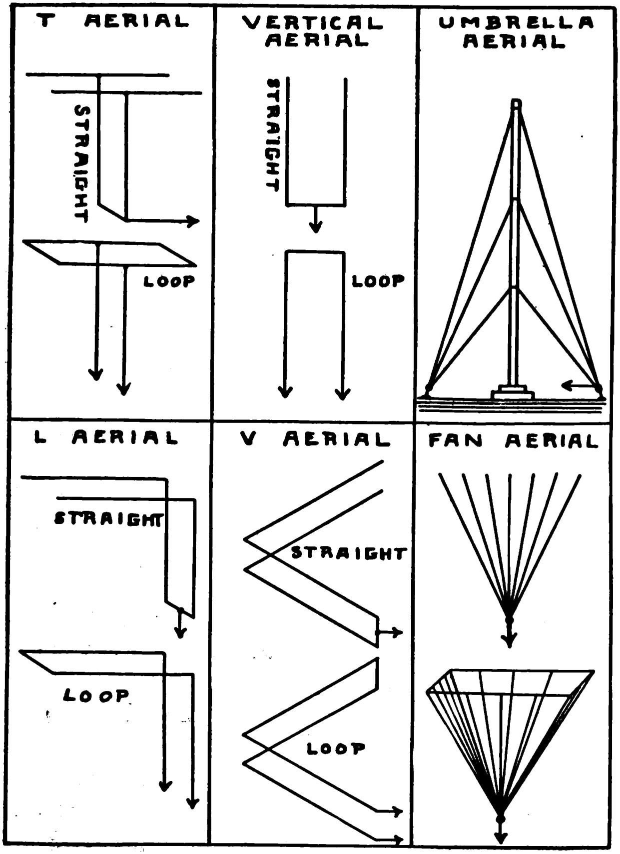


DIAGRAM OF AERIALS

After the *T*, the *Vertical* type has the greatest advantage, then the *Umbrella*, the *Fan*, and the *L* or *V* types. Questions of location are, however, very important in making this decision for any specified station, and may almost reverse this order.

T Type Aerials. For all-around work both in transmitting and receiving the *T* type is generally considered the most efficient. For the very best results the *T* aerial should be from 100 to 200 feet high and with a horizontal stretch of from 90 to 190 feet. From six to ten strands of nos. 8 to 12 wire should be used either in the loop or straight-away forms. These dimensions may be varied if the principal of a horizontal slightly shorter than the vertical is adhered to.

Vertical Type Aerials are not at all directional and are most excellent for general use. They may be in either the loop or straight-away form. This aerial is seldom used because of the difficulty of erecting. One very long pole is necessary. It should be from 75 to 200 feet high, of from six to ten strands of nos. 8 to 12 wire.

Umbrella Type Aerials. These are always good aerials and are inexpensive. They must be in the straight-away form. If instead of a pole, water conductor pipes are used, with four guy-wires at each joint, and both pole and guy-wires are insulated, the latter with strain insulators, the whole thing may be used as an aerial, and is very efficient. In size the

umbrella aerial may be from 50 to 150 feet. The guy-wires will have to be proportional to the height of aerial and the strain upon them. Phosphor bronze or galvanized iron wire should be used. For a 50-foot pole nos. 12 or 14 phosphor bronze would be sufficient, while for a 150-foot pole nos. 4 to 8 stranded steel cable is necessary. This type is becoming very popular.

The L or Horizontal Type Aerial may be either in the loop or straight-away form. It has the disadvantage of being somewhat directional. It should be about 100 feet long and 100 feet high, with eight to ten strands of 8 to 12 wire. This type is very common. It has often a length of 200 feet to a height of 50 to 75, which is all right for receiving, but is objectionable for sending.

The V Type of Aerial is used where the highest point must be near the station, with a lower point some distance away. This type is especially good in crowded quarters, and while slightly directional, gives excellent results. It should consist of six to ten strands of nos. 8 to 12 wire, about 100 feet long on each stretch. The height should be over 50 feet, and preferably 75 feet.

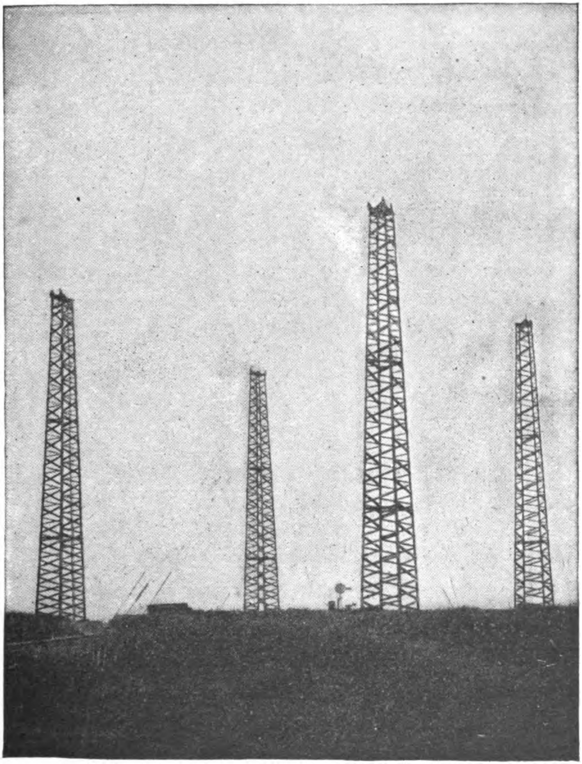
The Fan Type is especially good in crowded quarters also. It is not directional and must be of the straight-away form. It should be composed of from fifteen to twenty strands of nos. 12 to 14 wire and should be from 30 to 90 feet high. There are two kinds of fan-type

aerials — one consisting of a single fan suspended between two poles, the other formed of four fans suspended around four poles, such as is used in the Marconi Station in Wellfleet.

Almost as important as the comparative efficiency of different forms of aerials is the fitting of those types to the location of a station. All the surroundings must be considered and must have due weight in the final decision. The best location for a station is on a hill and near the seacoast. Directly on the seacoast or on an inland hill are both good locations. A wireless station in a forest or in the middle of a large city is at the very greatest disadvantage, since the trees and the trolley lines and iron frame buildings of the city absorb waves of almost any wave lengths in use, except the very long waves of a few such stations as Marconi and Fessenden.

If buildings are crowded together in a city or there are near-by trees, the umbrella type on top of the building will probably be advisable. Where great height cannot be obtained, the loop form should be used. The fan aerial is also very good under these circumstances. Long wave lengths for transmitting are necessary to avoid the absorption which shorter lengths would undergo amid crowded buildings.

In the country it is most desirable to get a location on a hill-top; and if possible, one free from trees. If guy-wires are attached to trees, a series of strain insulators should be placed between tree and aerial.



MARCONI STATION

Copper wire is the very best for an aerial. Next in conductivity comes phosphor bronze. Phosphor bronze wire should be used on all stretches of 100 feet and over. Aluminum wire is not as good a conductor as copper, although some of the larger sizes will do just as well. One of its advantages is its cheapness. It is very light also; eight or ten strands of aluminum wire cause very little strain to the cross-arm. Iron wire, because of a certain reactance effect, is a poor conductor and should not be used in the regular aerial, except in the umbrella type, where a great number are used in multiple as guy-wires. Only galvanized wire should be used.

Following is a list of the best sizes and materials of wires at best advantage in any good aerials.

	Size (B & S)
Copper wire, stranded, solid, or tinned	8–14
Phosphor bronze, stranded or solid	6–12
Aluminum, solid	6–12
Galvanized iron, solid (for umbrella type only)	4–10

Insulation for Transmitting and Receiving Stations. The proper insulation of an aerial plays a very important part in the transmitting as well as in the receiving distance. One of the greatest faults in the experimenter's transmitting station is that of leakage from improper or poor insulation. In erecting an aerial, two insulators should be used between each wire and the cross-arms. Not only that, but the ropes holding the cross-arms and all guy-wires should be

protected by petticoat strain insulators. The following is a list of the proper insulators for transmitting powers:

1 or 2 inch spark coil	......	wire cleats or spool insulators.
$\frac{1}{4}$ kw. set	....	2 inch strain insulators.
$\frac{1}{2}$ " "	....	2 " petticoat strain insulators.
1 " "	....	6 " " " "
2 " "	....	6 " " " "
3 " "	....	18 " " " "
5 " "	....	18 " " " "

To ascertain the total strain (T) upon the insulators, the following equation may be used:

$$T = \frac{L^2 W}{8S}$$

where L is the length of wire in feet, W the weight per foot in pounds, and S the total sag of the wire in feet. For example, if we have the following: Wire, no. 6; weight per foot, 0.112 lbs. (with insulators); sag, one foot; span, 100 feet,

$T = \frac{(100)^2 \; 0.112}{8 \times 1} = \frac{1120}{8} = 140$ lbs., total strain on insulators.

If an aerial is selected and erected according to these principles, the operator may be sure that he is getting approximately all the efficiency out of his station. As this is so important, he should take great pains in each part, in order that the result may be as faultless as possible.

Closely associated with his aerial efficiency is the adequacy of his ground connections. Although a good ground is nearly always easy to obtain, care should be taken in assuring oneself that it is a good ground.

The ground connections for sets up to one and two kilowatt should be made to water-pipes, with a

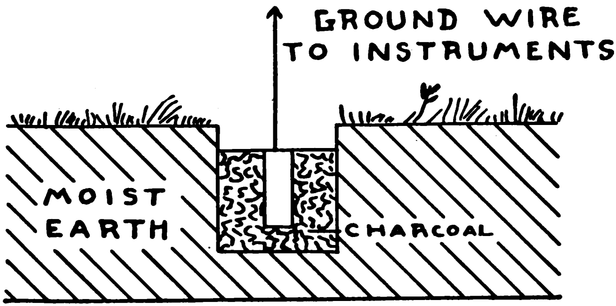


FIG. 47

no. 6 to 8 insulated wire. In all cases this ground connection should be made at or near the street side of the water-pipes, or where it enters the ground. Even a receiving station should be properly grounded in case of thunderstorms. Gas-pipes are not always an efficient ground, because they do not always form a sure connection; a certain red paint used in the joints sometimes acts as insulator. A water-pipe, on the other hand, is always a good ground.

A very good method of getting a ground connection for experimental purposes on a water-pipe is to scrape the pipe well and bind it with tin or lead foil. Upon this is wound a bright piece of new wire, the ground-wire. Another sheet of tinfoil outside is then covered with tape, if it is to be used permanently.

Where water-pipe grounds are not available, several methods may be resorted to. One way is to bury a copper ground plate in charcoal with a good-sized lead (wire 6–8) to the instruments. Another good ground for stations near the water is to throw overboard a large metal plate securely fastened to a substantial lead which runs to the instruments. Still another method, and the best, is to lay several hundred square feet of wire chicken netting over charcoal spread on the surface of the ground. This can be used even on sand, which forms the poorest connection possible.

When an efficient aerial and a good ground connection are secured, the operator may turn his attention to the installation of his station, which we shall proceed to treat in the following chapter.

CHAPTER VII

PROTECTION AND INSTALLATION OF A STATION

HAVING assembled all the separate parts of the wireless station, when the aerial has been erected and a good ground connection made, there still remains the by no means simple task of assembling them and of putting the completed station into working order. The steps in this process are first the protection and then the installation of the instruments in their places. Protection of a station includes both its preservation from lightning and also prevention of injurious effects upon the lighting system or the metres of the household. Installation of a station relates to the wiring of the transmitting apparatus both for alternating current and for direct current with interrupters, and then to the placing and wiring of the receiving apparatus.

Let us begin with the aerial. As it enters the station the aerial should be protected by a one-piece insulator. If, for instance, the wires are brought through the outer wall of the house, one continuous containing tube of porcelain, hard rubber, or electrose should extend four or five inches beyond either surface of the wall to stop any leakages of current. Small porcelain tubes may

be used on spark coils operated by battery current, but an electrose or hard rubber tube one inch thick should be used on sets of from ¼ to 1 kw.; for stations of from 1 to 3 kw. hard rubber or electrose insulation two inches thick is necessary; while for sets up to 5 kw. electrose insulators at least three inches thick all around the wire will be needed.

The wires for all leads from the aerial to the apparatus

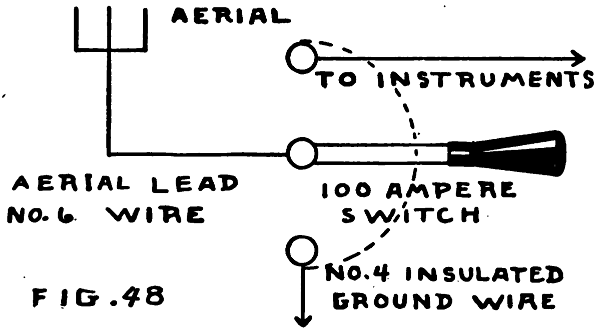


FIG. 48

should be of no. 6 copper wire, rubber insulated. Fire Underwriters' Rules declare that all aerial wire going into a station should be connected to a 100-ampere switch. This switch should be of the single pole double throw order, with the aerial connected to its centre or handle pole. It is advisable to use a double throw switch, since the instruments are entirely cut out when the aerial is grounded, which is not the case if a single throw switch is used. To the lower pole

should be connected an insulated, no. 4, ground wire, joined to the water-pipe on the street side of the water-metre, or to one of the ground connections described in the previous chapter. The upper pole of the 100-ampere switch is connected to the apparatus through the ordinary switches. In cities, Fire Underwriters' Rules order that this switch and the ground

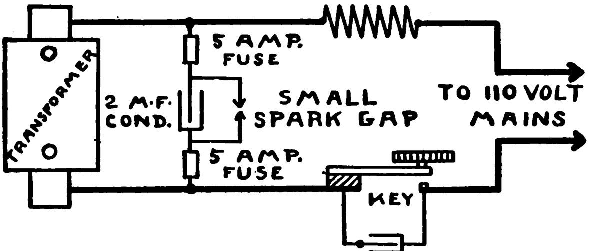


FIG. 49

wire be placed outside the station, and that the aerial be grounded when not in use.

The protection of a wireless station includes the safeguarding of the line and metres, of the key, and of the step-up or transmitting transformer. For direct current, little protection is necessary, but this is not the case where alternating current is used.

Thorough protection of the line, key, and transformer from $\frac{1}{4}$ to 5 kw. for alternating current are shown in Figs. 49 and 50.

The sending or step-up transformer should be shunted with two 5-ampere fuses and one 2-mf. con-

denser across which is a small protective spark gap, the whole connected in series across the primary of the transformer. This is the best protective device known, and will prevent all kick-backs. It will be found advisable to use a 1 or 2 mf. condenser across the contacts of the key, where these are not large enough to prevent its sparking or sticking.

The proper protection for the line is shown in Fig.

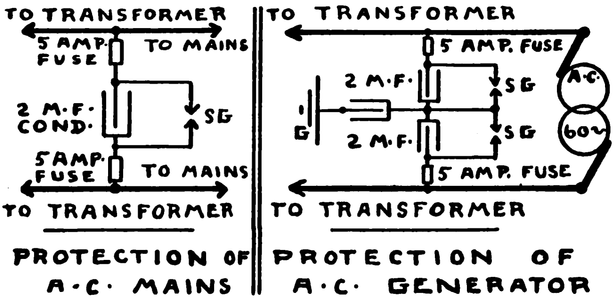


FIG. 50

50. This device is situated near the metres and consists of an arrangement similar to that placed across the transformer; two 5-ampere fuses are connected in series across the main line with a 2-mf. condenser. Across this condenser is placed another protective spark gap with a distance between the gaps of about $\frac{1}{64}$ of an inch. This device is sufficient to protect the line transformer and metres from any kick-backs in the circuit.

For the protection of an alternating current generator it is necessary to use a more complex arrangement of fuses, condensers, and spark gaps. Across the generator are placed two 5-ampere fuses and two 2-mf. condensers in series. Across these condensers in turn are two protective spark gaps. A connection between the two condensers is grounded through a third 2-mf.

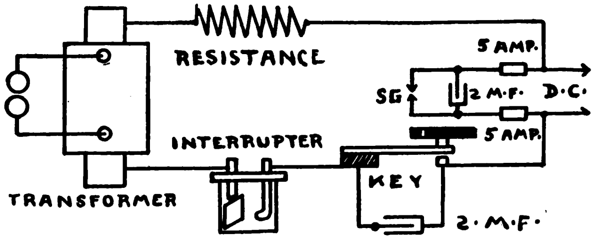
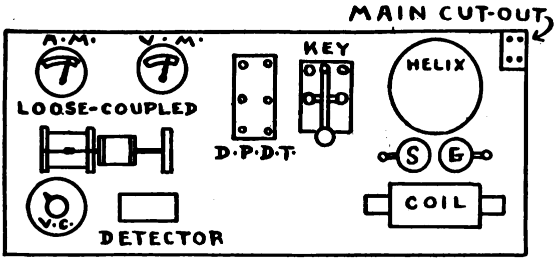


FIG. 51

condenser. This device is especially for motor generator sets and affords adequate protection there.

With direct current somewhat simpler safety devices are necessary. Direct current, however, is not nearly so good as alternating current, for some kind of an interrupter must be used in order to obtain the pulsating current described in Chapter I. Fig. 51 shows a method of protection for direct current. The key is shunted with a one or two microfarad condenser, while the main line has two 5-ampere fuses in series, with a condenser and protective spark gap. This affords sufficient protection for ordinary circuits.

Installation. A broad table is the best thing for mounting the instruments of a wireless station. If this is used the convenient position of the instruments may be easily determined, and by judicious grouping a slight movement of the hands will control them all. All of the switches used in changing from sending to receiving should be beside the key, in order to facilitate the operator's movements. The most convenient

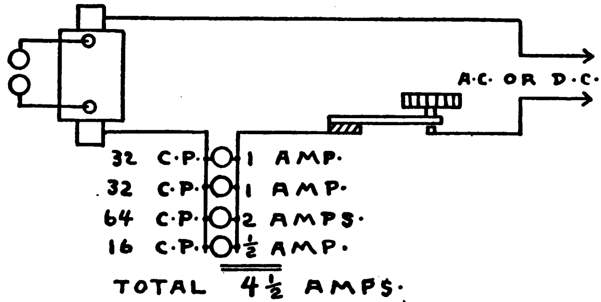


OUTLINE OF INSTALLATION
FIG. 52

arrangement places the transmitting apparatus at the right and that for receiving at the left.

All connecting wires for the transmitting apparatus should be rubber insulated, no. 14, stranded, copper wire. Porcelain or hard rubber insulators are necessary where the wires pass through the table. Care must be taken in wiring underneath the table, as well as on top. On the extreme right is the main cut-off for the sending instruments. If an electrolytic

interrupter or a rotary converter is used, it should be encased beneath the table, where it will be out of the way. Where alternating current is used reactance regulators will cut down the current. With sets from 2 to 5 kw. these are of the best advantage. However, reactance regulators are expensive and hard to build, so a bank of lamps may be used for resistance with



LAMPS USED AS RESISTANCE
FIG. 53

small sets using either alternating or direct current. An 8-candle-power lamp allows a ¼-ampere current to pass; one of 16 c.p. allows ½ ampere; one of 32 c.p. allows a full ampere to pass. If we want a current of 4½ amperes, then, we place in the circuit one 64 c.p, two 32 c.p., and one 16 c.p. lamps, thus securing the necessary amperage.

The receiving apparatus, we have decided, will be on the left of the table. In wiring up, rubber covered,

no. 16 or 18, stranded, copper wire will be necessary. The leading wires of the receiving instruments should be placed on top of the table, so as to leave the under side clear for the transmitting wiring.

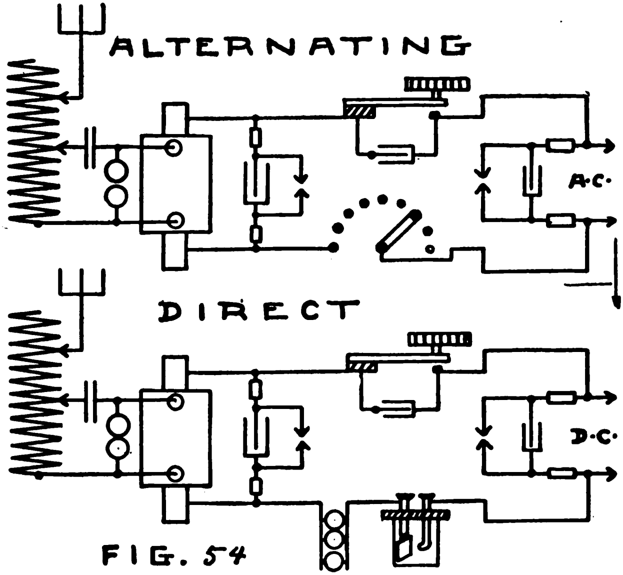


FIG. 54

All leads both for sending and receiving apparatus should be as short as possible. For these and the connections the operator is strongly advised against using the tinsel telephone cords, their resistance being very high.

If pains are taken in following these directions, and

a careful study is made of the diagrams, the operator will find every instrument in his station within easy reach of his hand. Variations may sometimes be advantageous under special circumstances, but for ordinary use experience has shown the placing of every instrument as shown in the diagrams.

Fire Underwriters' Rules. Following are the regulations regarding the matter issued by the Fire Underwriters:

In setting up wireless telegraph apparatus (so called), all wiring within the building must conform to the rules and requirements of the National Board of Fire Underwriters governing the class of work installed and the following additional specifications:

I. Aerial conductors to be permanently and effectively grounded at all times, when station is not in operation, by a conductor not smaller than no. 4 B. & S. Gauge copper wire run in a direct line to a water-pipe, at a point on the street side of all connections to said water-pipe within the premises; or to some other equally satisfactory earth connection.

II. Aerial conductors when grounded as above specified must be effectually cut off from all apparatus within the building.

III. Or the aerial to be permanently connected at all times to earth in the manner specified above, through a short gap or lightning arrester; said arrester to have a gap of not over .015 of an inch between brass or copper plates not less than 2½ inches the other way with

a thickness of not less than $\frac{1}{8}$ of an inch mounted upon non-combustible non-absorptive insulating material of such dimensions as to give ample strength. Other approved arresters of equally low resistance and equally substantial construction may be used.

IV. In cases where the aerial is grounded as specified in no. I, the switch employed to join the aerial to the ground connection shall not be smaller than a standard 100-ampere jack-knife switch.

V. Notice of wiring done for these installations should be sent to the board, the same as for all other electrical work.

CHAPTER VIII

OPERATION OF A STATION

If good care is taken of a station, it will generally work to its highest advantage. The operator should see that his apparatus is carefully handled at all times and that his transmitting apparatus is always in proper resonance. This chapter will take up not only general questions of care of instruments, but it will deal with tuning devices suitable both for fine apparatus and for the more inexpensive instruments. Hints on the improvement of a station's working will be no small part of this chapter's interest, and in this respect we are now coming to what is perhaps the most important part of the subject.

No general suggestions can apply both to transmitting and receiving apparatus, since the range of distance covered by the two is always different: Therefore we shall take up the two in turn, dealing with the separate parts of our subject-matter first as applied to sending and then to receiving.

Transmitting Apparatus. The working of the station depends largely upon the care that is taken of it, and for that reason apparatus should at all times be kept

free from dust. This is especially true of all spark gaps, the large one used for transmitting, and all small protective gaps. If dust collects between the sparking surfaces, it acts as a conductor, the gap is short-circuited, and then the fuses blow or burn out. Once the adjustments of the spark gaps are made, these should be boxed in and left alone. Wherever also there are small contact points, as in the vibrator or key, a particle of dust may cause considerable trouble.

Operation of transmitting apparatus does not lie in the manipulation of the key so much as in tuning up the helix or condenser. This tuning up of the apparatus brings the helix into resonance with the aerial and with the condenser. It is the most important factor in operation and is one requiring skill and experience.

The theory of resonating or tuning up the transmitting apparatus is as follows: The helix has three contacts, a ground connection, which should be stationary, and two variable connections, one in series with condenser and spark gap, another leading to the aerial (see Fig. 55). The helix is thus divided into two parts or inductive fields, one included between ground and condenser, the other between ground and aerial. These are called inductances (L^1 and L^2). The aerial ordinarily acts as a condenser so that now we have two groups or circuits, consisting, in the first place of the aerial condenser (C^2) and helix inductance (L^2), which act as a secondary; in the second place of the condenser (C^1) and the inductance (L^1), which act

as a primary. These two circuits must be equalized to secure good results, *i.e.*

$$\underset{\text{secondary}}{C^2 \times L^2} = \underset{\text{primary}}{C^1 \times L^1}.$$

Bringing this condition about by manipulating the helix contacts is called *tuning*.

The variation in the condenser (C^1) and helix (L^1) necessary to secure the same value as the aerial (C^2)

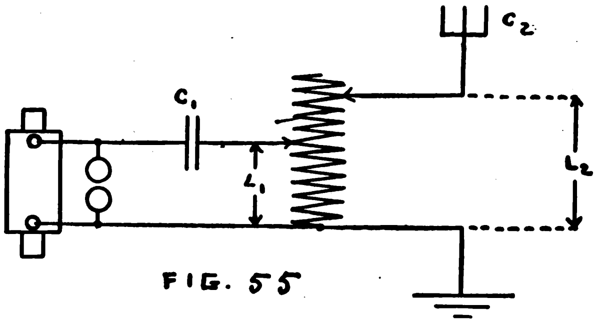


FIG. 55

and inductance (L^2) may be done theoretically either in the condenser or in the helix. Practically, however, it is so much easier to move the helix contacts than to cut tinfoil off the condenser plates that the helix is almost always made variable, the condenser stationary. Further, it is necessary to notice that the relative position in the circuit of spark gap and condenser is unimportant and may be changed.

There are several methods of tuning both with the helix and with the oscillation transformer. Two spe-

cial instruments are used in tuning, the Geissler tube and the hot-wire ammeter, the latter being the more efficient.

The Geissler Tube is a glass tube, in both ends of which are sealed electrodes, generally of platinum. The air in the tube being exhausted or nearly so, a spark will readily jump between the metal electrodes in the rarified air. If a slight current is passed through, a faint light is diffused throughout the tube. Increase in its light marks the passage of a stronger current,

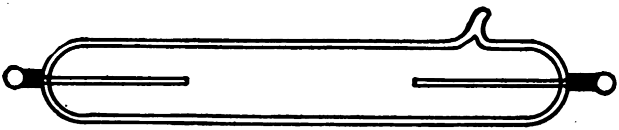


FIG. 56

and the maximum brilliancy marks the highest point of a high frequency current. A *Geissler tube* of plain design is shown in Fig. 56.

The Hot-wire Ammeter is a much more delicate instrument. It depends upon the fact that a German silver wire will expand when heated even slightly. A simple form is shown in Fig. 57, but all such instruments work on variations of the same principle. A German silver wire is stretched between two points (A and B), to the middle of which is attached another wire connected to the end of a fine aluminum needle (D). This needle turns on a pivot or fulcrum (F) and

is shown on the dial scale (E). Now if the instrument is connected in an electrical circuit, a slight current passing through (A) and (B) expands the g.s. wire, which lets down the wire (C) and causes the aluminum needle (D) to deflect from the point of

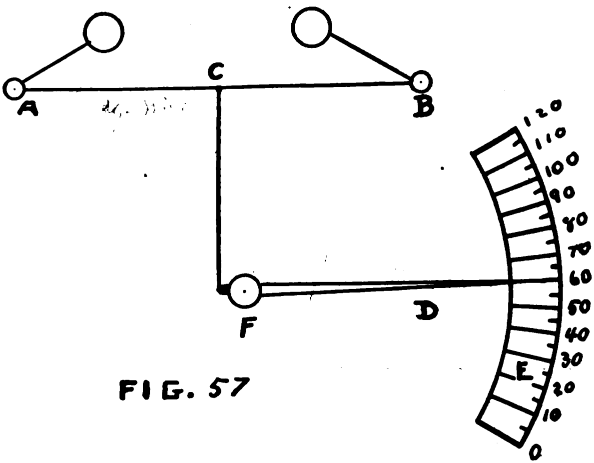


FIG. 57

equilibrium (o°). Where the needle shows the greatest deflection will be the point of greatest current strength. Since the ammeter is very delicate, a variable resistance should be shunted across it, to prevent burning out the wire.

The first step in tuning is to move the condenser clip (B) on the helix until a desired wave length is obtained. Thereafter this clip will remain fixed.

Across the helix, between helix and aerial, is now placed this Geissler tube, which shows by its point of greatest brilliancy the exact position for the clip (A). When

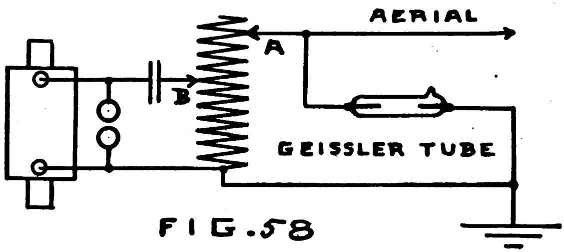


FIG. 58

tuning-in the circuit, the light in the tube may be lessened in intensity by decreasing the spark gap. By moving the aerial clip (A) on the helix, with a faint light in the Geissler tube, it will be easy to find the point where a perfect balance occurs, by the maximum

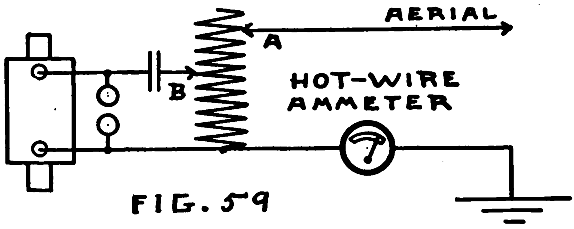


FIG. 59

brilliancy of the tube. This is the point of finest tuning or resonance.

A second method of tuning the helix, by using a *hot-wire ammeter*, is better and more exact (Fig. 59).

The ammeter should be placed in the ground circuit, or between ground and aerial, the former method being preferred because the apparatus can then be handled if necessary. This would not be so if it were in the aerial. First fix the wave length desired by the condenser clip (B). Then by moving the aerial clip (A) up and down the helix, we find different degrees of deflection in our ammeter needle. Where that deflection is greatest, the current is strongest, and there we will place clip (A). It should be noted in both cases where tuning up with a helix that either clip (A) or (B) may be used to determine the wave length, the variation being made by the other clip.

With the oscillation transformer the use of tuning instruments is much the same. However, it is possible to secure resonance by the aid of a small auxiliary spark gap, and without special instruments when a transformer is used in place of the helix. This method is shown in Fig. 60. In tuning the oscillation transformer, a test spark gap is placed across the secondary, *i.e.* between aerial and ground. The condenser clip (B) on the primary of the transformer sets the wave length. The secondary is tuned with the aerial clip (A). By operating the key, and at the same time watching the discharges at the auxiliary spark gap, we will find where they are most rapid. In repeating the process the point of highest resonance may be found. This method of tuning is, however, by no means easy, and considerable quickness is required to

count the dots of the key and at the same time note the discharges at the gap. It is advisable only because of the simplicity of the instruments.

When using the Geissler tube with an oscillation transformer, it should be placed in exactly the same position as the auxiliary spark gap shown in Fig. 60.

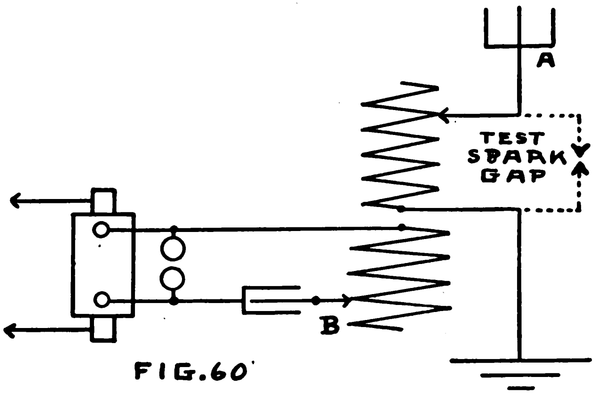


FIG. 60

The maximum brilliancy will show the point of highest resonance for the secondary, the primary determining the wave length by the condenser clip (B).

The hot-wire ammeter is placed in the ground circuit connected with the primary of the oscillation transformer and is used in the same way as with the helix, the condenser clip (B) setting the wave length as in previous examples.

Still a third method of tuning up is as follows: An

ordinary $1\frac{1}{2}$-volt Tungsten lamp placed in the ground circuit is bridged with a variable resistance. As you press the key and at the same time vary the resistance, the point of brightest light having the lowest resistance

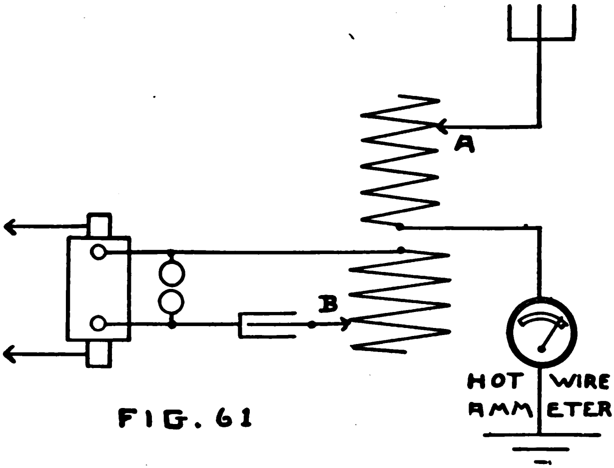


FIG. 61

will show best value of balance and the best position for clip (A).

The coupling between primary and secondary should be carefully regulated, so that the two coils be far enough apart to secure sharp tuning, and at the same time be near enough to prevent too great loss of energy. If the two coils are too far apart, they will lose part of the inductive effect upon each other; that is, they will be out of inductive range. If they are too near

together the secondary's reactance on the primary will cause a hump in the wave, and two points of tuning will be the result, the stronger point representing the main tuning point, and the weaker one showing the split or division of energy.

With the transmitting instruments perfectly tuned,

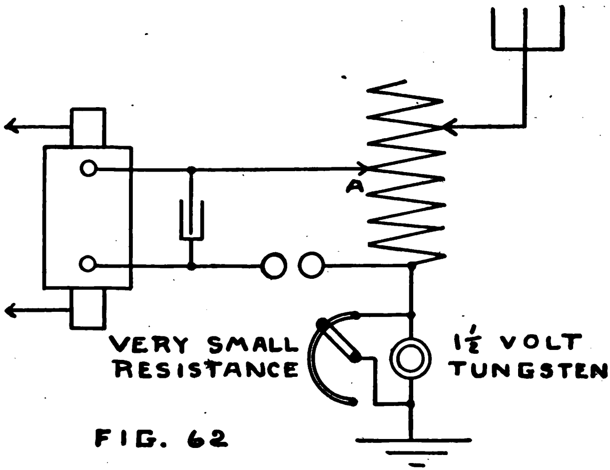


FIG. 62

it is necessary only to manipulate the key quickly and easily. This is, of course, largely a matter of quickness of movement and practice. The matter of the various codes now in use will be further discussed in Chapter X.

Receiving Apparatus. The operation of receiving apparatus consists principally of bringing the instru-

ments into resonance with those of a transmitting station whose messages we desire to receive. In theory the tuning of receiving apparatus is the complement of that of transmitting. Waves of a certain length are sent out from the transmitting station, and the receiving station must be able to catch them on its aerial acting again as a condenser. The tuning coil, acting as an inductance, is joined with the aerial and enough additional condenser value to balance the incoming waves. This condenser value may be supplied by variable or fixed condensers added to the circuit.

Operation of the receiving apparatus includes the manipulation of tuning coils and oscillation transformer, of the variable condenser, and of the detector in order to secure the correct amount of inductance and capacity (aerial condenser and coil inductance) to receive the incoming waves. This manipulation depends upon the type of coil, so that it seems best to consider the tuning of each one independently. In general, it may be said that the slides of the coil or the oscillation transformer should first be brought roughly into tune with the station sending, then the variable condenser should be brought to the point of highest resonance before adjusting the detector.

The Single Slide Tuning Coil is most frequently used without a variable condenser. Under such circumstances there is only one movement to be made, one slide to be moved. (Fig. 63.)

The Double Slide Coil should be used with a variable condenser, although of course fair results may be obtained without. The clips are lettered (A) and (B). A rough adjustment is found with (A), and this is made more sharp by (B). The last and finest adjustment is made with the variable condenser (VC). (Fig. 64.)

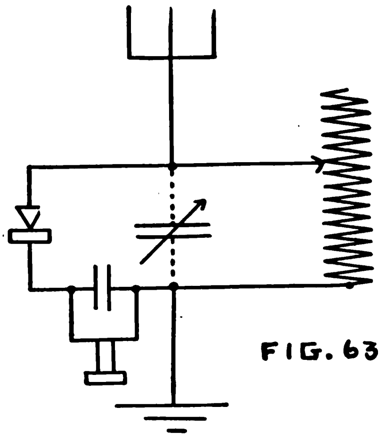


FIG. 63

The Three Slide Tuning Coil has an effect similar to the *Loose*-coupled coil, but it is not so selective; *i.e.* it will not bring in one station without interference so well as the latter. In Fig. 65 are shown the three slides; the ground clip (A), between which and the aerial is formed a primary circuit; the distance between clips (B) and (C) forming the secondary circuit, while the coupling is regulated by varying the distance

between (A) and (BC). The first adjustment, which is only approximate, is obtained with (A). Then a more careful tuning is secured by moving (B) and (C) together. The finest adjustment is then made with the variable condenser (VC). Finally a closer adjustment

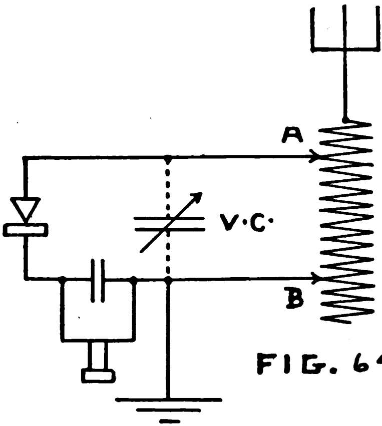


FIG. 64

of (A) may be made, and this completes the tuning of the circuit.

The Loose-coupled Tuning Coil or *Receiving Oscillation Transformer* is much more delicate in its adjustment than any other and is far more easily manipulated. It is the only tuning device to be recommended for good work. The first thing is to obtain the desired station roughly with the slide (A) on the primary. Then the switch (B) on the secondary should be varied,

followed by the regulation of the coupling (K) between the two coils. After this the variable condenser will be adjusted. And finally a further fine variation on the primary will give us the greatest strength of signals.

The Use of Two Receiving Oscillation Transformers: The Weeding-out Circuit. By placing a second oscilla-

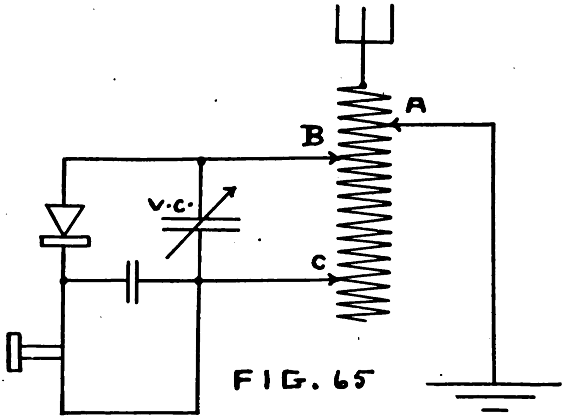


FIG. 65

tion transformer in series with the first one (see Fig. 67), greater selectivity still can be obtained, although at some slight loss of energy in the strength of signals. The first adjustment is made on the primary (A). Then either (C) or (B) should be moved and a finer balance found with the variable condenser (D). The slide (E) on the secondary is then regulated to balance this coil with the previous ones, by an additional

movement of the second variable condenser (F). The tuning is so sharp in this circuit that it is necessary to go over the manipulation of these variations a second and even a third time to secure the greatest value.

A Tertiary Weeding-out Circuit is occasionally used for extreme cases, but the increased loss of energy is a serious drawback to its usefulness, except where

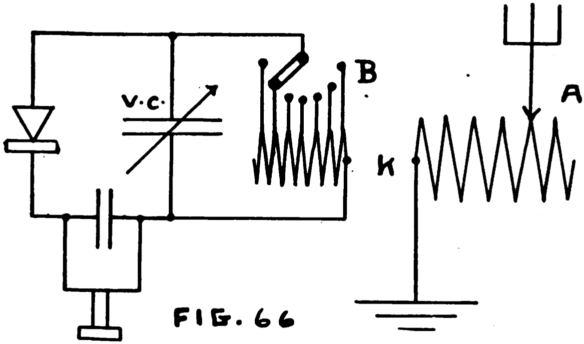


FIG. 66

interference is unusually bad. Adjustment is made by the same routine as in the first weeding-out circuit, with the addition of another oscillation transformer and variable condenser. The circuit is shown in the chapter on diagrams.

The Detector will be used in every case, as the last and final adjustment. If the surface of the mineral in a silicon or perikon detector be covered with a thin film of Atlas Oil No. 2, its action will be increased and the mineral's rectifying qualities will be preserved.

Some of the perikon detectors now in use by the government show the mineral entirely immersed in oil, and this form has given great satisfaction when used. *Molybdenite*, which occurs in closely packed layers, should have a sharp knife-edge resting against the cross-section of these layers. Good silicon should

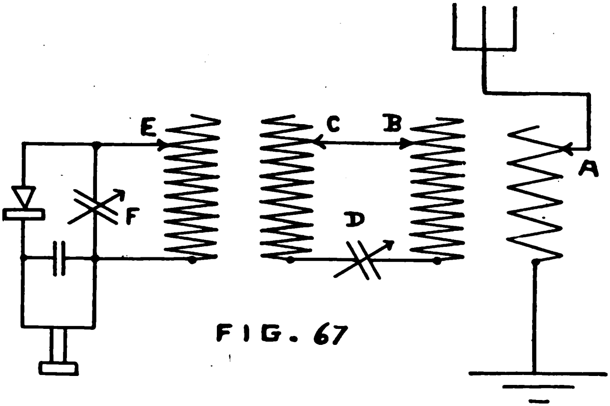


FIG. 67

be free from flaws. An artificial or polished surface is the best for contact with a spear-point. The oval fractures of iron pyrites or pyron should come in contact with a spear-point such as is used for silicon. There are several kinds of zincite, only one of which is good for use in perikon detectors. This occurs in layers of some thickness, which should be turned edgewise in contact with a sharply pointed piece of bornite, both of these minerals being used in their natural

fractures. By adjusting the detector carefully, testing meanwhile with a buzzer, the most sensitive point may be found; and this, as we have already stated, should be retained as long as possible.

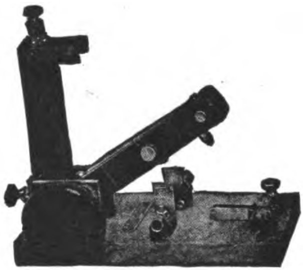
Adjustment and operation of both sending and receiving apparatus is of the highest importance for good results in wireless. The importance of carefulness and fine manipulation cannot be over-emphasized. Recognition of this and the skill, which are learned only after considerable experience, show the division between the real operator and the amateur, in the worst sense of the word.

CHAPTER IX

BREAKING-IN SYSTEMS: METHODS OF SIMULTANEOUS RECEIVING AND TRANSMITTING

In transmitting wireless signals we have always the sending station, from whose aerial are sent out waves of a definite length in every direction. Now it is as easy to receive such signals to the north as to the south of the station, the only limitations being caused by the limits of power of the sending station's electrical apparatus and its distance from the receiving station. Thus all wireless messages are sent out in circles around the transmitting aerial. If there are many such stations close together, the result would be pandemonium but for the fact that sending stations may regulate their wave lengths and thus avoid interference to some extent. It has long been the ideal of wireless experiment to find some method by which the receiving station may be tuned in to a certain sending station, regardless of the fact that other stations nearer at hand and perhaps of greater power were sending at the same time. To some extent this differential tuning is now possible, but only in cases where waves of very different lengths are coming in

at the same time. For instance, if the Marconi Station (Cape Cod, Mass., with a wave length of 1800) is sending at the same time as the Charlestown, Mass., Navy Yard (at a wave length of from 320 to 560), a receiving station in Boston will be able to cut out one or the other, provided he has a Loose-coupled Tuning Coil. But if the Navy Yard is sending at the same time as the Board of Trade Building, Boston



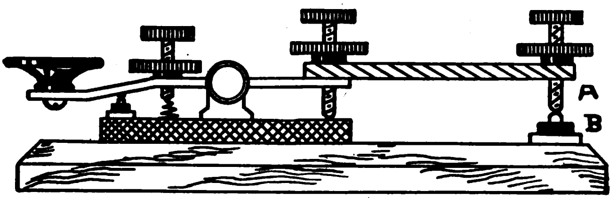
HAND THROW SWITCH

(about 700 metres wave length), it will be almost impossible to tune the stronger station out and receive only the weaker one.

If tuning devices can ever be brought to the perfection necessary to secure such fine tuning readily, every wireless man will be glad. But meanwhile we have a present condition of affairs, and what can be done to obviate interference or make it less annoying is every man's quest. Breaking-in Systems, while not yet generally popular, seem destined to supply this

need, and are increasingly used every day. If they do not prevent interference, they at any rate make it impossible except consciously.

The Breaking-in System is a method of simultaneous transmitting and receiving wireless signals; that is, a device is placed between the sending and receiving sets so that the operator may receive incoming signals even while he is sending them out. This device con-



SIMPLE BREAK KEY
FIG. 68

sists usually of some attachment to the key which automatically switches in the transmitting circuit every time the key is pressed, and also automatically switches in the receiving circuit every time the key is released, even between the dots and dashes of the code.

Its advantages are more or less obvious to every operator. To the government or any commercial station, the breaking-in system has the advantage that if serious interference occurs in the course of a long message, that fact may be signalled to the sending operator. Thus the latter will stop until elimination

of the interference, and so save the time and current which would otherwise be used in completing a message which the receiving station could not pick up. On the other hand, a breaking-in system will notify an experimenter or private operator when more important

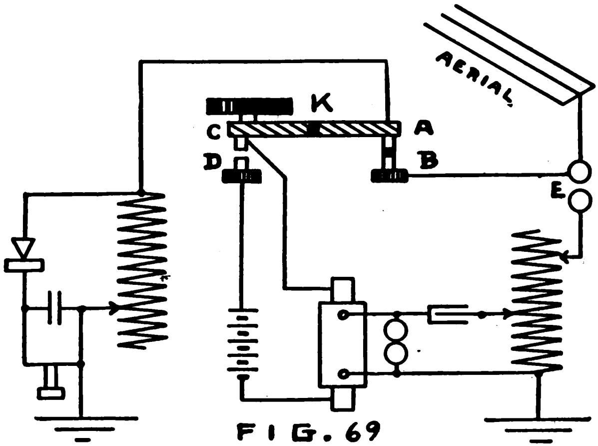


FIG. 69

stations are sending. He will, as a matter of course, stop sending with wave lengths near those of the professional stations, and thus will cease to make himself a nuisance and a subject for hostile legislation.

Methods of breaking-in are determined partly of course by personal choice, but much more by the power of the transmitting apparatus. Thus we will take up three or four of the best ways, appropriate for different sizes of instruments.

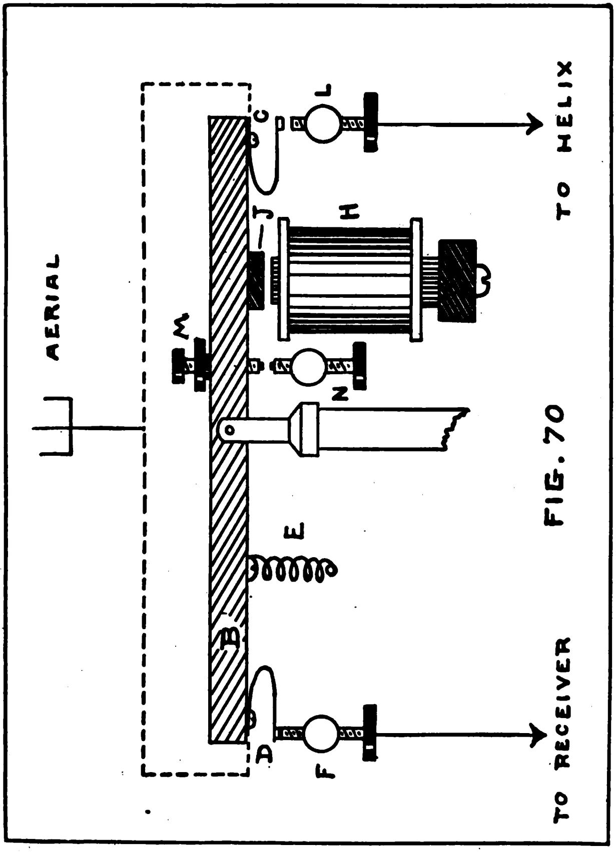


FIG. 70

For a One-inch Spark Coil a simple mechanical device is all that is necessary. Such an arrangement is shown in Fig. 68. It consists of a short strip of $\frac{1}{8}$ inch fibre, half an inch wide and four inches long, and an adjustable contact (A) below which is a stationary contact (B). Fig. 69 shows this key in the circuit. When the key is at rest, contact (A) will be on contact (B), thus connecting the aerial with the receiving set. On pressing the key (K), the contact (A) is raised away from (B), breaking the receiving circuit. Then contact (C) touches (D) and completes the transmitting circuit. The device must be adjusted so that the connection of (A) and (B) will be broken before (C) touches (D), otherwise the current will pass into the receiving set, breaking down the detector and disturbing the operator. A small auxiliary spark gap (E) between helix and aerial connects the latter with the transmitting set when the key is closed and insulates it from the same set when the key is open.

For a Two-inch Coil this method would be inadequate. An electrical device like that shown in Fig. 70 is, however, suitable for such a coil or one somewhat larger. This break consists of an insulating rod (B) supported in the centre. The aerial is connected to contacts (C) and (D) on either end of the rod. A spring (E) holds the rod down at one end, the receiving end, where the circuit is made through contacts (D) and (F.) The opposite end of the rod may be pulled down by an electro-magnet (H) operating on an armature (J).

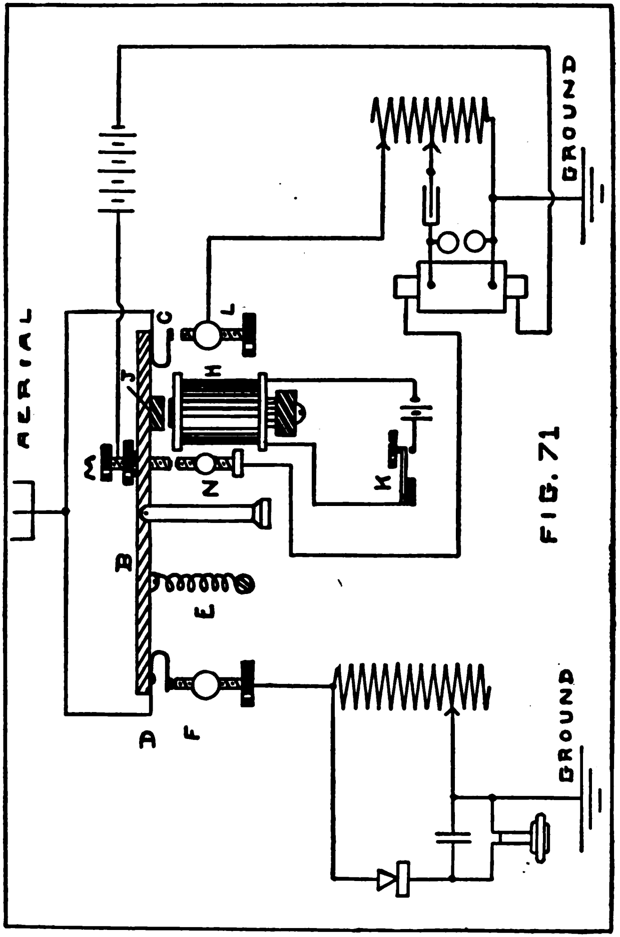


FIG. 71

When this end of the rod is brought down, three things occur: the contact (D) and (F) is broken, and contact is made between (C) and (L), and (M) and (N). Fig. 71 shows this device in the circuit. With the key at rest, the spring (E) holds the contact (D) on (F), thus connecting the aerial with the receiving set; the contacts (MN) and (CL) being open and consequently cutting out the transmitting set. If the key (K) is pressed, it operates the magnets (H) through the local circuit. Then this magnet, acting on the armature (J), reverses the pull on the rod. Now contact at (D) and (F) is broken, and the receiving side is cut out. Meanwhile connection is made between (M) and (N), and this turns on the primary current, and the aerial is connected to the transmitting side through the contacts (C) and (L). This break must be adjusted so that the contacts (D) and (F) be broken, and those of (C) and (L) made before that made at (MN); otherwise the same results as those previously mentioned will follow, and the operator will receive a shock.

For Transmitting Stations up to 1 kw. a form of break permitting greater insulation is necessary, and another variation of electrical device has been arranged especially for small transformers. By the addition of more insulation and certain protective devices this break may be used up to 2 kw.

In the break (Fig. 72) as adapted for a 1-kw. transformer the following description holds good. The key (K) has two sets of contacts (AB and CD), of

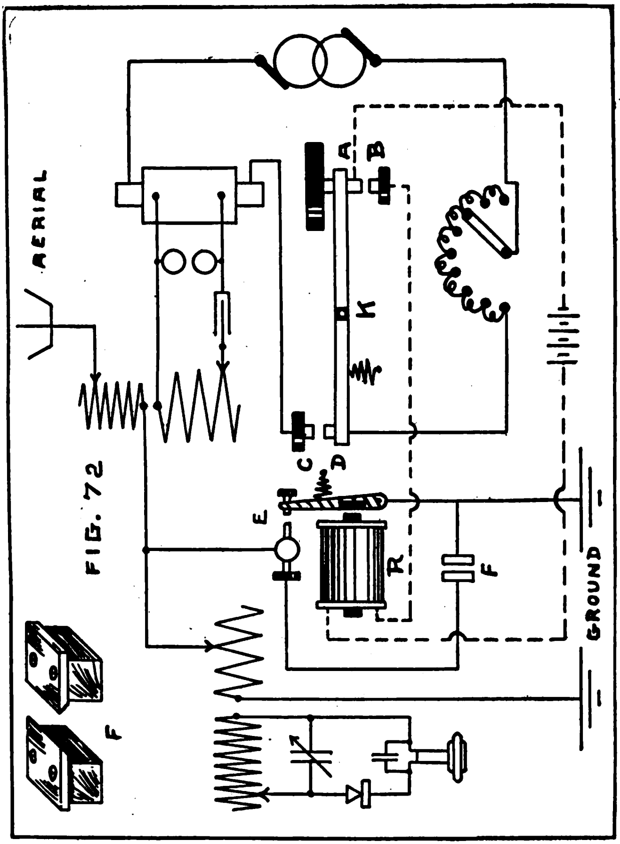


FIG. 72

which the latter are very heavy. When the key is at rest neither of these contacts is closed, but the aerial is connected directly with the receiving side. When the key (K) is pressed, the local circuit is closed through the relay (R), thus grounding the secondary of the oscillation transformer through the relay contacts (E). The contact (CD) being formed, closes the primary circuit and operates the transformer. It is necessary, as in previous examples, that contact (AB) be made before (CD), and for the same reason. An adjustable protective spark gap (F), consisting of two knife-edged brass plates mounted on hard rubber blocks, is placed across the relay contacts (E) for protection to the operator in case the contact (CD) should be made before (AB).

For Stations of 5 kw. the great current requires very complete protective devices, and it is especially necessary that the adjustment of the detector be protected from the influence of the powerful transformer.

This form of break is shown in Fig. 73. When key (K) is at rest, the contacts (AB) and (CD) leading to the transmitting circuit are open, and the aerial is connected to the receiving set through the contacts (EF). When the key is pressed, contacts (AB) close the local relay circuit, thus grounding the aerial by contacts (FH) and protecting the detector by the relays (R^1R^2). Just afterwards, (CD) being closed, completes the primary of the transmitting circuit. Contacts (AB) should be made before those of (CD) or some of the transmitting

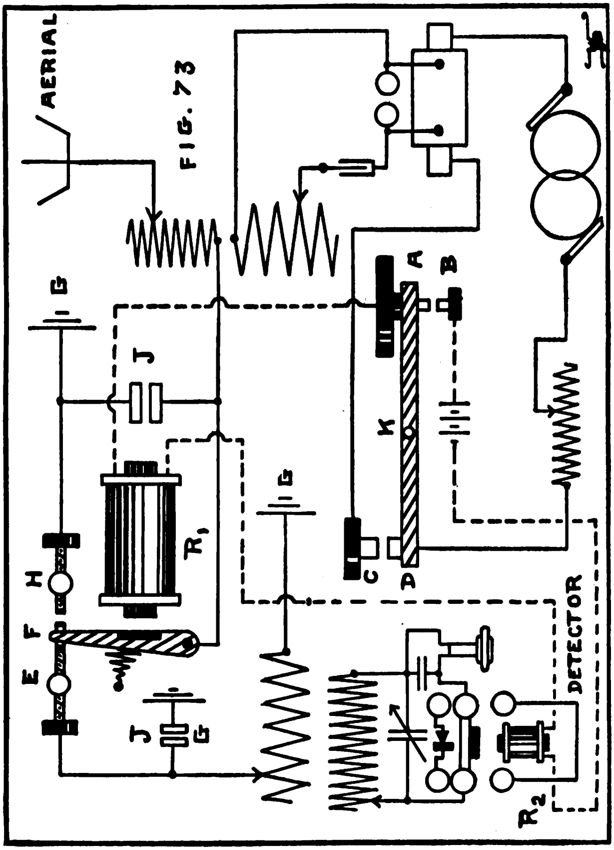


FIG. 73

current will jump the contacts (EF) and enter the receiving set. However, the knife-edged protective spark gaps (JJ), previously described, are used to prevent this in some measure.

Great care should be taken to protect the detector in all stations of over 1-kw. capacity. Even the pyron and perikon-elektra detectors (whose stability is great) will not retain their most sensitive points beside transmitting stations of this size. A protective device for a detector is shown in Fig. 74. This consists of a relay operating a double pole, double throw switch to cut the detector out of the circuit entirely when sending. At the same time the switch closes the receiving circuit so that no influence will be directed upon the detector, which is screened by a metallic box (E) having two leads (AD) insulated by hard rubber bushings (JJ). The connections (AD) project beyond the bushings about a quarter of an inch to serve as contact points in the relay device. This relay device consists of a magnet (M) which acts on an armature (H) supporting two contacts (BE) which are insulated from each other by a hard rubber standard (K). Two adjustable contact points (C and F) are placed to make contact with (BE) when the key is pressed. Then these points are strapped together or short-circuited. The operation of the break is thus simply explained. If the key is at rest, the magnet (M) is dead, so the spring will hold the contacts (DE) and (AB) closed, connecting the detector in the receiving circuit.

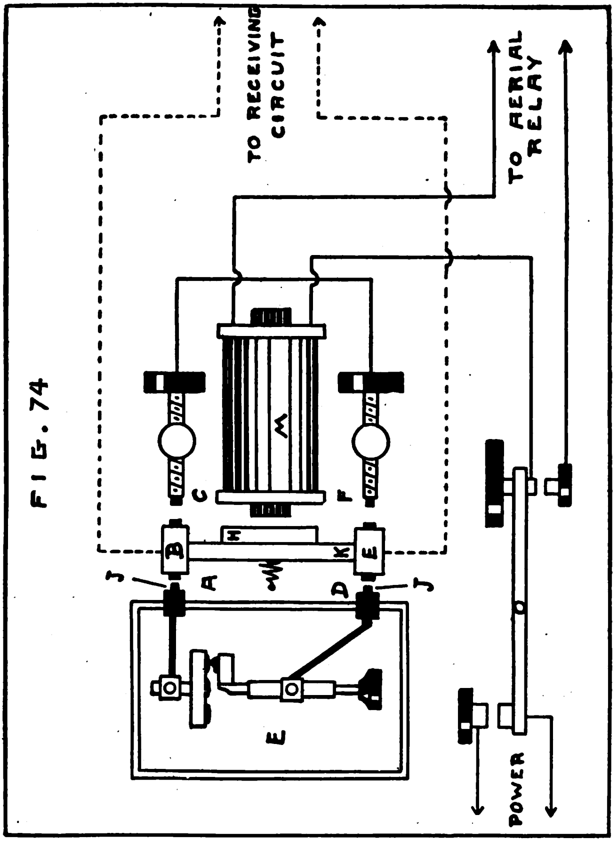


FIG. 74

If, on the other hand, the key is pressed, it will close the local circuit and excite the magnet (M). This pulls the armature (H) forward, disconnecting the detector and closing the receiving circuit by contacts (B and C) and (E and F). These actions break the detector from the circuit and leave it screened or protected from the powerful electrical discharges of the transmitting apparatus. At the same time the receiving circuit is closed and this prevents any influence upon the points (AD) which might occur if the contacts (BE) were open and not closed by CF.

When the silicon or perikon detectors (zincite and bornite type) are used, it will be necessary always to use this protective device shown in Fig. 74, the stability of these detectors being poor as compared with the sealed point electrolytic, pyron, and perikon-elektra detectors. Any of these latter forms may be used on stations up to 1 kw. without any protection except a relay to short-circuit them.

Some of these last diagrams may seem complicated. When the reader, however, stops to think of the problem of switching the aerial between transmitting and receiving, while at the same time protecting himself and the instruments with a single movement of the key, he will understand why such care is taken. It is also necessary that the break work quickly enough to allow incoming signals to be heard even between the dots and dashes of an outgoing message.

CHAPTER X

CODES

Codes are merely generally recognized systems of short and long signals, "dots and dashes," arranged to correspond with the letters of the alphabet, numerals, and punctuation marks. By means of these "dots and dashes;" a sending operator is enabled to spell out messages to a receiving operator. As codes are only arbitrary agreements, it might be possible to have as many as there are operators or sets of operators, and every one could use a different one. In practice, however, it has been found convenient to use certain generally recognized systems, which become as familiar as a language to every telegraph operator.

There are three of these systems in general use in America—the American Morse, the Continental, and the Naval Codes. The most popular in America is the Morse, although the Continental is used to a considerable extent, especially in wireless telegraphy. The Continental Code is generally used in Europe, and in England is called the Morse, while that code called Morse in America is spoken of as the American Morse. The Naval Code is used officially by the American Navy, but is surpassed in popularity by both the other

codes even in the Navy. The Continental and the Naval Codes have one point of similarity in that none of their letters are spaced (*i.e.* include spaces as well as dots and dashes), as does the Morse. The three are shown together on the following pages.

THE CODES

Morse		Continental		Navy	
A	.—	A	.—	A	——
B	—...	B	—...	B	—..—
C	.. .	C	—.—.	C	.—.
D	—..	D	—..	D	———
E	.	E	.	E	.—
F	.—.	F	..—.	F	———.
G	——.	G	——.	G	——..
H	....	H	....	H	.——
I	..	I	..	I	.
J	—.—.	J	.———	J	..——
K	—.—	K	—.—	K	—.—.
L	——	L	.—..	L	——.
M	——	M	——	M	.——.
N	—.	N	—.	N	..
O	. .	O	———	O	—.
P	.....	P	.——.	P	.—.—
Q	..—.	Q	——.—	Q	.—..
R	. ..	R	.—.	R	—..
S	...	S	...	S	—.—
T	—	T	—	T	—
U	..—	U	..—	U	..—
V	...—	V	...—	V	.———
W	.——	W	.——	W	..—.
X	.—..	X	—..—	X	—.——
Y	.. ..	Y	—.——	Y	.——
Z	... .	Z	——..	Z	———

1	.——.	1	.————	1	....
2	..—..	2	..———	2	————
3	...—.	3	...——	3	...—
4	....—	4	....—	4	———.
5	———	5	.....	5	..——
6	......	6	—....	6	——..
7	——..	7	——...	7	.———
8	—....	8	———..	8	—...
9	—..—	9	————.	9	.—.
0	———	0	—————	0	—..—
.	..——..	.	.. .. ..		
,	.—.—	,	.—.—.—		
?	—..—.	?	..——..		
!	———.	!	——..——		
¶	————	;	—.—.—.		
		&	...—..—		

The first necessity for an operator is, of course, to learn thoroughly some one of these codes. As the Morse is so much the more popular, we shall take that for illustrative material, although similar groupings may be made of the Continental. Fig. 76 gives a convenient grouping of the characters which adds to quick memorizing, and acts as an aid to the memory as long as such an aid is of use.

A CONVENIENT GROUPING OF MORSE CHARACTERS

The Dot . E The Dash — T

All Dots

C	E	H	I	O	P	R	Y	Z	6
.. .	.	....	..	. .	.....	. ..	.. ..	... .	......

All Dashes

L	M	T	5	0	¶
———	— —	—	— — —	————	— — — —

Spaced Letters

C	O	R	Y	Z
· · ·	· ·	· · ·	· · · ·	· · · ·

For Memorizing

E	I	S	H	P	6	T	L	0
·	· ·	· · ·	· · · ·	· · · · ·	· · · · · ·	—	———	————

Dash Followed by Dots

N	D	B	8
— ·	— · ·	— · · ·	— · · · ·

Dots Followed by Dash

A	U	V	4
· —	· · —	· · · —	· · · · —

Contrasting Characters

A	N	B	V	C	R	D	U	F	K	G	W	J	,	Q	X
· —	— ·	— · · ·	· · · —	· · ·	· · ·	— · ·	· · —	· — ·	— · —	— — ·	· — —	— · — ·	· — · —	· · — ·	· — · ·

Since every word in telegraphy must be spelled out, certain abbreviations have become generally recognized both in wire and wireless telegraphy. These abbreviations most used in ordinary telegraphy have usually been adopted in wireless, but there are additions, like the famous C. Q. D. (S. O. S.), for special wireless needs. The use of these saves considerable time, and the opera-

tor should learn to use them. Every line of business has special signs used frequently in its own business. We include here, however, only the general abbreviations, and the operator will make his own special additions.

ABBREVIATIONS

3 or 30	Finish signal
73	Accept my compliments.
ANS	Answer
BK	Break
CK	Check
DH	Free
FM	From
GA	Go ahead
GE	Good evening
GM	Good morning
GN	Good night
HR	Another message
IMPT.	Important
MIN.	Minute
NM	No more
NO	Number
OFM	Official message (used only by the navy).
OK or II	All right
OFC or OFS	Office
OPR	Operator
PD	Paid (generally in full).
QN and QJ	Beginning and ending of quotations.
SIG	Signature
SOS	International distress signal.
SVC	Service
V	Test letter.
X or 99	Interference.

In operating a wireless station, certain forms of messages are absolutely necessary; and in general practice commercial stations have adopted those forms used by the ordinary telegraph companies. Variations are, of course, required, and the following message-form (Fig. 77) will answer the needs of any commercial wireless station.

Such a form, however, is rather more elaborate than experimenters will ordinarily require for private signalling. For such operators, nevertheless, some formality is advantageous, and a simple question and answer form like the following may be adapted to personal needs.

1. Call of station wanted (three times) . . . . . . CN, CN, CN.
2. Sign call of sending station (once) . . . . VA
3. Finish signal . . . . 3 or 30

RECEIVING OPERATOR

a. call of sending station (three times) . . . . VA, VA, VA.
b. Sign call of receiving station (once) . . . . CN.
c. All right . . . . OK. OK.
d. Go ahead . . . . GA. GA.
e. Call of sending station (once) . . . . V A
f. Sign call of receiving station . . . . C N
g. Finish signal . . . . 3 or 30

SENDING OPERATOR

4. Call of station wanted (three times) . . . . . CN. CN. CN.
5. Period (repeated two or three times) . . . . Period. Period.
6. Body of message . . . .
7. Period . . . . Period. Period.

NUMBER	SENT BY	RECEIVED BY	CHECK	TIME	STATION VIA
H.R. 1 S.N.	FS	SY	Ck. 7 Paid	6.26 P.M.	New York

BOSTON, MASS.........................19....

To *J. Jones*, *Key West, Florida*.

All are well will return at once.

Sig. *James*.

NM meaning no more, or HR meaning another message.

HR = Message

1 = Number of Message

S N = Sending Station's Call

F S = Sending Operator's Sign

S Y = Receiving Operator's Call. To be filled after the message is copied

Ck = Check

7 = Number of words in body of message

Paid = The message may be either paid, collect, or service.

Time = To be filled in by receiving operator, after the message is copied

If message is relayed

FIG. 77

8. Sign call of sending station....................V A.
9. Finish signal................................3 or 30

Receiving Operator

h. All right. (If message is received and understood) *O K. O K.*
i. Call of sending station......................V A. V A.
j. Sign call of receiving station ....C N. C N.
k. Finish signal ....3 or 30

or,

Question (if message is not understood and must be repeated) *D N. D N.*
i. Call of sending station....................V A. V A.
j. Sign call of receiving station................C. N. C N.
k. Finish signal................................3 or 30

Sending Operator

10. All right (sending operator will repeat) ......O K. O K.
11. Call of receiving station.....................CN. CN.
12. Sign call of sending station....................V A.
13. Period ....Period
14. Repeats body of message, and ends as before (8, 9)

CHAPTER XI

THE ETIQUETTE OF WIRELESS AND THE SUBJECT OF INTERFERENCE

THE air is free to all, or at any rate it has been thought so until discussion upon wireless interference has become of importance. Now we have the knowledge that in England a license fee is charged, for the use of the air presumably, whenever a wireless station for transmitting is installed. Many bills on the same subject have been proposed in America, but up to the time of printing, without result.

There is, moreover, some justice on the part of those who wish to limit the use of the air in this way. Since the loudness of signals depends upon the power of the transmitting instruments and the distance to be covered, it is possible for private persons and commercial companies to monopolize the space in certain vicinities, so that a most important government message cannot be received. It is, of course, to be understood that the government should have right of way, not only in the roads, but in the air.

Interference may be of two kinds, unintentional or malicious. In their effect there is no difference; but

as a matter of fact, it is the unintentional interference of experimenters unversed in the code, and without adequate breaking-in systems, that has given rise to most of the legislation hostile to them. Malicious interference either on the part of an experimenter or, as frequent complaints bear witness, on that of commercial stations, should be dealt with as severely as possible. It would seem that license restrictions would be too mild a treatment for such cases, and in all probability a method of dealing with them will be evolved.

In cases of unintentional interference, there is usually no remedy, as it is by an experimenter, or where the station is not properly equipped. No person should operate a transmitting set until he has a proper understanding of the codes, and, if he has no breaking-in system, without *listening-in* frequently to learn whether other stations are trying to make themselves heard. It is while a station is trying to receive messages from a distant source that interference is most objectionable. While a powerful station near you is sending, a sending station of less power or different wave length may send without troublesome effect; but when it is trying to get signals from a weaker station, or one at some distance, your interference will be most effective and most disastrous.

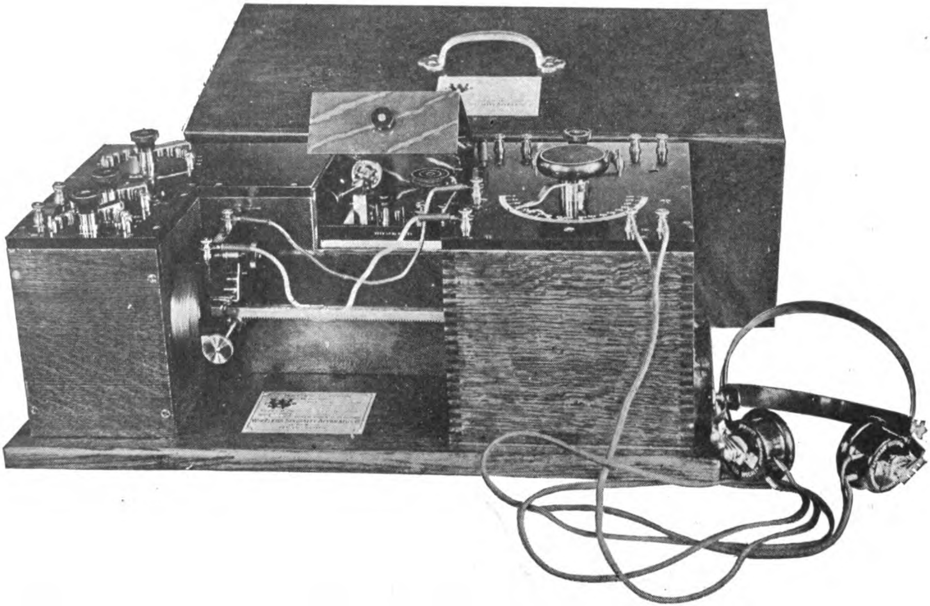
There are, however, some methods of overcoming interference. If the experimenter will use an oscillation transformer for sending, he will be able to tune his

apparatus much more sharply. With a sharply tuned wave length, he will be received only by apparatus tuned in with his instruments most exactly. Therefore, if he is from fifty to one hundred metres either above or below the commercial station, he may be tuned out without trouble at the receiving instruments.

Another method of overcoming interference is by the new duplex system of wireless, where two aerials are used, one for sending and the other for receiving. The shorter aerial is for sending, thus ensuring a short wave length, much below that of the commercial stations. The longer aerial, for receiving, may be as large as is desired or needed, according to the distance to be covered.

Still another method is by the use of a breaking-in system, which will enable the experimenter to hear distant sending stations when they call, even while he is sending.

Where interference occurs with the government or commercial stations, a weeding-out or third (tertiary circuit) should be used. This will make the tuning of the receiving instruments twice as sharp as with the ordinary receiving loose-coupled transformer.



WIRELESS TELEGRAPH AND TELEPHONE RECEIVING SET AS USED BY UNITED STATES GOVERNMENT

CHAPTER XII

WIRELESS TELEPHONY

THE Wireless Telephone is not yet a success. Various interesting experiments have been made on theoretical principles, and for short distances speech has been transmitted, or at least musical tones have been identified. Much more experiment, however, is necessary before it will be possible to use the wireless telephone even to the extent that we can now use the wireless telegraph.

Distances up to a hundred miles have been claimed by some commercial companies, although it is doubtful whether, on test, telephone transmission has been made for such a distance. Moreover, the principle now most popular with experimenters (the so-called "arc method") does not promise much more in the matter of distance even under the best of conditions. For short distances, however, the wireless telephone has been used, and speech has been distinctly heard for twenty miles certainly. Any greater distance than this is a matter for proof and speculation. This was done by using the arc method, which will be later described. By the disruptive discharge method,

greater distances can easily be covered, but articulation is poor. Professor Fessenden's new system promises improvement in both respects.

The earliest experiments along the line of telephoning without wires were devoted to what we now call

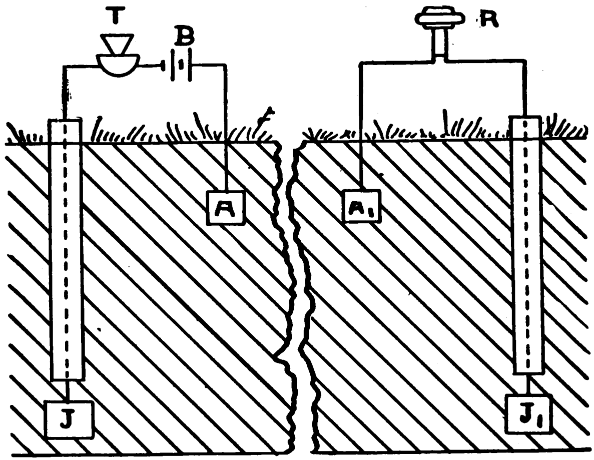


FIG. 78

the "conductive" method of wireless telephoning. The connecting medium, in this case, is the ground. The diagram (Fig. 78) will show the working of the system. A plate (A) buried about three feet below the surface of the earth is connected through a set of batteries (B) and a telephone transmitter (T) by a highly insulated lead-wire to another plate (J) buried

in the ground at a distance of some fifteen feet. A duplicate arrangement on the receiving side leads from a plate (A′) through a receiver (R) to another plate (J′). When a current is set up in the transmitting side, it is conducted by the surface of the earth from A to A′; after passing through the metallic connections to J′ it will find its way back again to J, and a circuit will be established. Now if we speak into the transmitter (T), we will vary the current over this

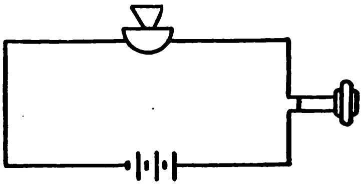


FIG. 79

circuit, and our speech will be heard in the receiver (R). As a matter of fact, the conductive method really amounts to the circuit shown in Fig. 79, the earth forming the connecting medium between both sets of plates. This method will work up to about three miles.

Another early form of wireless telephony both in point of original experiment and of electrical importance is the Static Telephone. This form, shown in Fig. 80, works on the principle of the condenser. A wire frame or grid, consisting of lines of wire, and having the effect of an almost solid metallic surface,

is charged through an induction coil by the human voice. This charge on the grid (A) charges a second grid (B), which is connected to a receiver, and the speech is distinctly transmitted by *electro-static induction.* The effect is represented in our second dia-

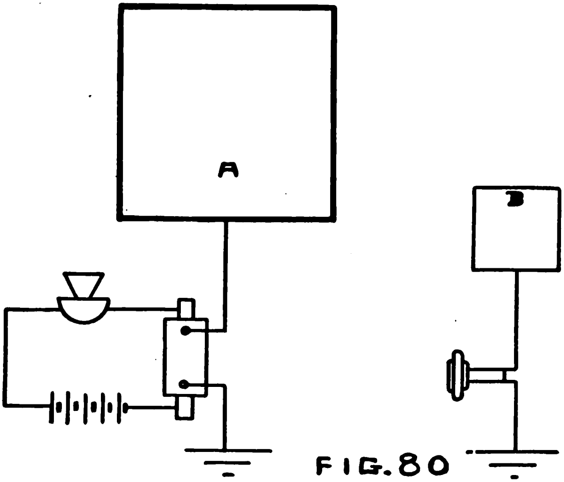


FIG. 80

gram (Fig. 81), the two grids acting as the plates of a condenser. This will work up to a half mile.

Still another form of wireless telephone works on the principle of the induction coil, by *electro-magnetic induction.* (See Fig. 82.) A loop of heavy copper wire about five feet in diameter, connected to a telephone transmitter of low resistance and a battery, forms the

transmitting side. The receiving end consists of a similar loop of wire attached to a telephone receiver, which should be of the bi-polar type, and must be wound

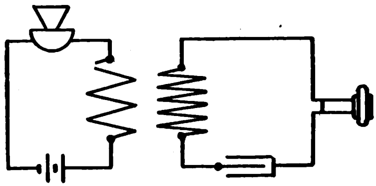


FIG. 81

with about no. 18 wire. The transmitting side acts as the primary, the distance between the two loops as the magnetic field, and the receiving loop as the secondary of the induction coil. It is to be noted

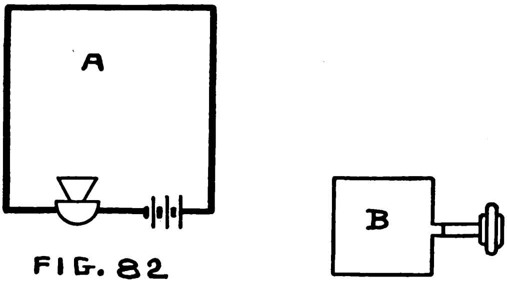


FIG. 82

that in both instances we are dealing with low resistances. This is to avoid the losses of energy caused by a great number of turns of wire in the circuit. For

the same reason we use heavy loops of wire, a low resistance telephone transmitter and receiver, and batteries in series multiple. The effect of this form of telephone is shown in Fig. 83. This will work up to three or four miles.

The smaller illustrative diagrams (Figs. 79, 81, and 83) show in graphic manner that no one of these methods of telephony depends upon the action of the high-frequency waves used in wireless telegraphy. In each of these methods the plates must be arranged in

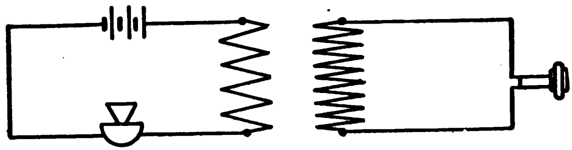


FIG. 83

a certain manner. The four grounded plates used in the first, *conductive method*, must be in a plane, with the upper plates at a similar distance underground, and the lower plates in like manner. The grids of the *static form* may be different in size and relative position above ground, but it is essential that the transmitting end be higher than the receiving. The loops used in the last, or *inductive method*, must be either in the same or parallel planes, as no indications will be received if they are at right angles, a fact true of the induction-coil principle.

Although none of these use detached electro-mag-

netic waves, there are methods of wireless telephony, or rather we should more properly say *Radio-telephony*, which do make use of those waves. Two or three of these wave methods are of importance, and most of the experiment now going on relates to them.

First of these is the *Spark Method*. In passing from our description of the wireless telegraph, this

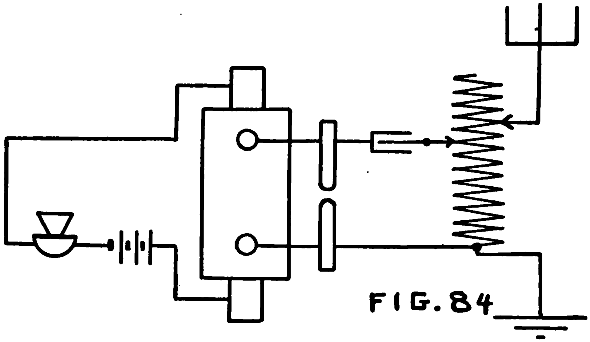


FIG. 84

method is simplest. It may be used with an ordinary transmitting circuit (Fig. 84) by the addition of a telephone transmitter of special design in the primary. The vibrations of the voice speaking into this transmitter are stepped up to a higher voltage by the spark coil, and are recorded in the spark gap. This gap, which may be of the ordinary form, or may consist of two small carbon rods, should be connected in an oscillatory circuit of almost any design, with aerial and ground connections. Fig. 85 shows a more efficient

form of telephone working on the same principle. This is the telephone designed by the author and consists of a special telephone transmitter (A), a variable impedence (B), connected with a battery (C) in the primary circuit. Any vibrations received in the transmitter are picked up by the secondary and are discharged through the mercury-vapor spark gap (D). This

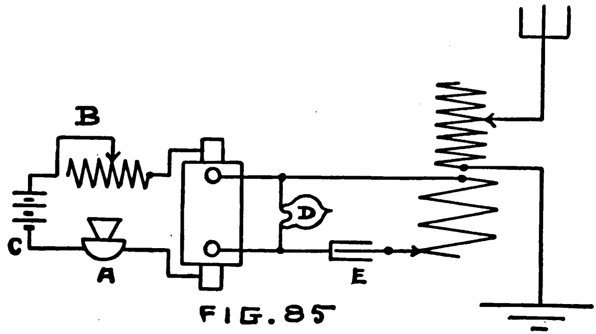


FIG. 85

discharge in the mercury-vapor tube sets up oscillations in the circuit, which in turn are picked up by the aerial circuit and radiated off into space. Such a telephone will transmit messages from five to fifteen miles. The ordinary tones of the human voice both in speech and in singing, and the notes of musical instruments, especially the xylophone, are revealed very clearly through this mercury-vapor spark gap, but articulation is sometimes indistinct.

The Arc Method works by the production of un-

damped oscillations. This is most popular at present with experimenters, and several wireless men in America are working with it. A form of arc generator shown in Fig. 86 consists of a singing or musical arc burning in hydrogen gas. This arc will produce oscillations when connected with a coil and condenser, thus forming an oscillatory circuit. An induction

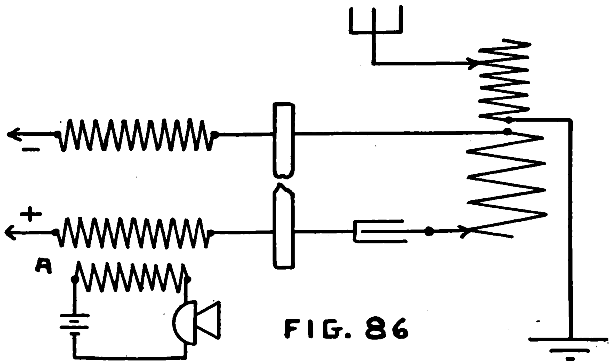


FIG. 86

coil (A) is placed in the power circuit between the arc and the power supply. In the primary circuit of this is placed a battery and a telephone transmitter. The vibrations of the voice speaking into the telephone transmitter and varying the current about the arc cause fluctuations in the arc corresponding to those in the transmitter. These variations, communicated to the oscillatory circuit, are picked up by the aerial circuit and radiated from the aerial. Speech is very

clear when using this method, and it has been used up to fifteen or thirty miles. It is often called the speaking arc.

Another arc method is illustrated by Fig. 87, consisting of an arc generator and a transmitter in the

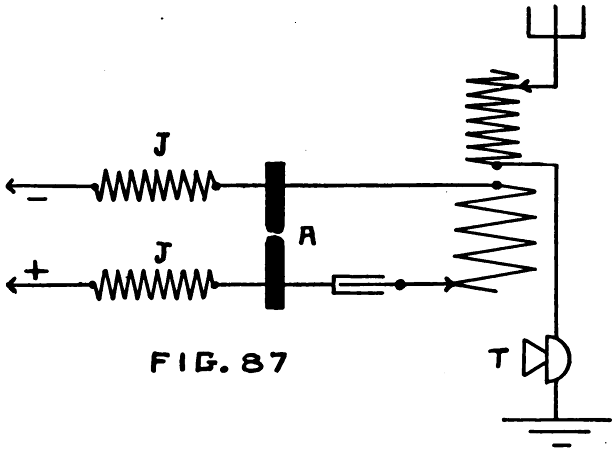


FIG. 87

aerial circuit. An ordinary direct current supply is used and two impedences (JJ). The arc (A) is water cooled, in order to keep down heat disastrous to the production of oscillations. This arc generates best when running on from four to five amperes and not over 220 volts; anything in excess of this tending to destroy the generating properties for some unknown reason. The arc must be kept at its greatest length,

as at that place it generates best. The frequency of the arc (A) ranging between 100,000 and 200,000 per second, the electro-magnetic waves follow each other so closely that the effect upon the telephone receiver is continuous. Now if we speak into the transmitter,

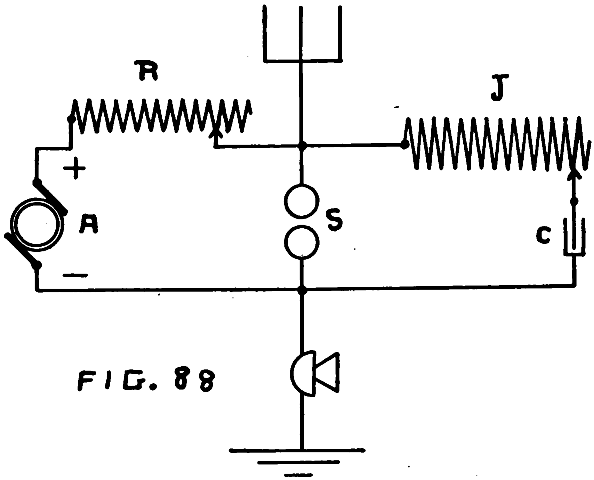


FIG. 88

placed in the aerial circuit, the vibrations of the voice will interrupt these waves, and the interruptions will be audible in the telephone receivers as words. This is the method used by De Forest. Experiments with this system have covered distances of perhaps twenty or thirty miles, due to the limitations of the current in a secondary circuit.

Fig. 88 shows Professor Fessenden's Wave-Generator, one of the latest and most ingenious methods yet produced. A direct current dynamo (A), of about 5000 volts potential, is connected to a spark gap (S) through a variable resistance (R). Across this gap is placed a coil (inductance) (J) and a condenser (C). The telephone transmitter is placed in the ground circuit. The spark frequency of this device is governed by the resistance (R), so that we can jump from a frequency of one spark to one of 100,000 per second. The working theory of this plan is that the current from the dynamo flowing through the circuit slowly charges the condenser through the resistance (R). When a charge in the condenser becomes great enough to overcome a set distance between the gaps, a spark will jump across and will excite a current in the oscillatory circuit. The greater the resistance in the circuit, the longer it will take to charge the condenser, and the fewer the sparks per second across the arc. If the resistance is low, on the other hand, the condenser will charge and discharge itself very rapidly across the gap. When a frequency of from 80,000 to 100,000 is obtained, the waves, following so rapidly, are inaudible at the receiving end, and an almost continuous current is made. The vibrations of the voice speaking into the transmitter interrupt or vary the intensity of the continuous waves, and speech is thus transmitted.

In all forms of wireless telephony a special kind of

transmitter is not only advisable, it is actually almost necessary. There has been considerable experiment as to the kind of transmitter best adapted to the purpose, and numerous modifications of the ordinary transmitter are the result. A type which can be used

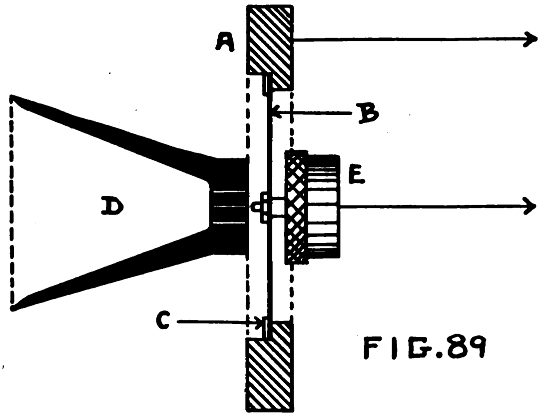


FIG. 89

with all the methods of telephony described is shown in Fig. 89.

This transmitter, which is of the inertia type, works very well for all experimental purposes, although for permanent use the solid back type might perhaps be advisable. This inertia transmitter should have a very massive frame of the ordinary type for long distance use. The diaphragm (B), about .006 inch in thickness, of French steel, should be held firmly in

place by a metallic ring (C). The mouthpiece (D), of ordinary type, must be so arranged that the distance between it and the diaphragm may be varied. The transmitter button (E), attached to the centre of the diaphragm, is shown separately in Fig. 90. This button consists of a cup or carbon chamber (A), an insulated face-plate (B), and a cap (C). The carbon chamber (D) and the face plate (E) should be made of platinum, although silver-plated brass is

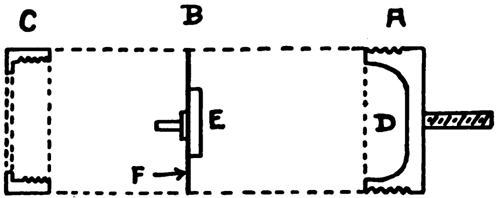
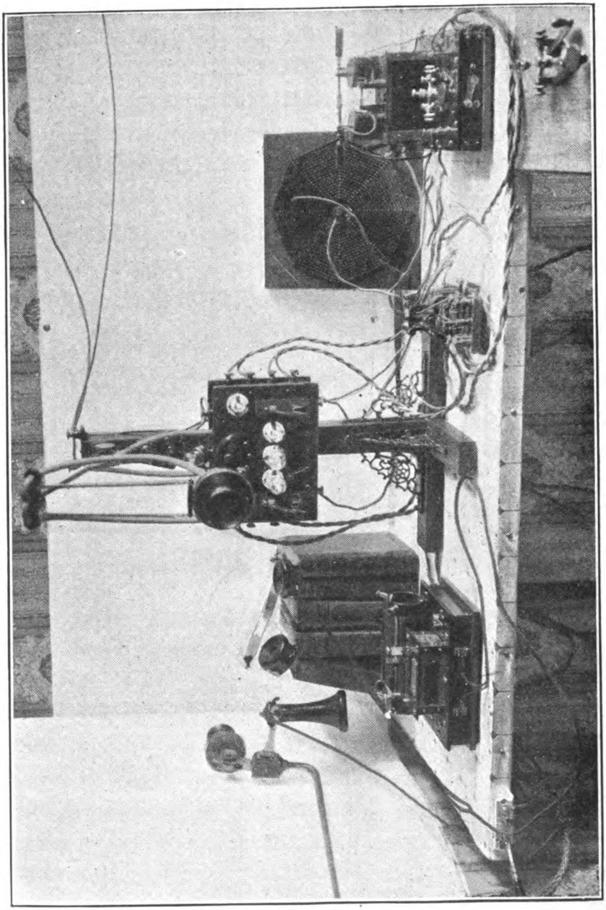


FIG. 90

very good. The inside diameter of the carbon chamber (D) should be about $\frac{5}{8}$ inch, while the distance between the back of this chamber and the face plate should be $\frac{1}{8}$ inch when the cup is closed. The face-plate, backed with a thin mica washer (F), which supports and insulates it, is held in place by the cap (C). The carbon granules will be large and globular when used in the primary circuit, and the chamber should be well filled with them. When used in the aerial circuit they should be much smaller and should only partially fill the chamber. The thinness of the mica washer is

of importance, in order to ensure the greatest amount of vibration reaching the granules.

For receiving wireless telephone messages, any of the detectors and any of the receiving circuits shown in the back of the book may be used successfully.



APPENDIX

AERIALS

The *T*, the *Vertical*, the *Umbrella* are the best types of aerials.
The *L*, the *V*, the *Fan* are all good types.
Combinations of types are often best fitted for a specific location.

TRANSMITTING CIRCUITS. I

1. Spark Coil, Spark Gap. The simplest circuit.
2. Spark Coil, Spark Gap, Condenser. The addition of a condenser to give a longer wave.
3. Spark Coil, Spark Gap, Helix. Addition of a helix to give longer wave.
4. Spark Coil, Spark Gap, Condenser, and Helix. The combination of instruments for the best results.

Any of these circuits may be used on a one-inch spark coil for distances of from one to two miles; but they are not practical for greater distances, and do not give the full value of the instruments.

TRANSMITTING CIRCUITS. II

5. Spark Coil, Spark Gap, Helix, and Condenser. A practical circuit for a 3-contact helix.
6. Spark Coil, Spark Gap, Helix, Condenser, and Anchor Gap. For use with loop aerials and breaking-in systems. A practical circuit.

7. Spark Coil, Spark Gap, Condenser, 3-Contact Helix. A popular and practical circuit.

8. Spark Coil, Spark Gap, Condenser, 4-Contact Helix. Circuit especially adapted for the variety of its effects.

All practical circuits.

TRANSMITTING CIRCUITS. III

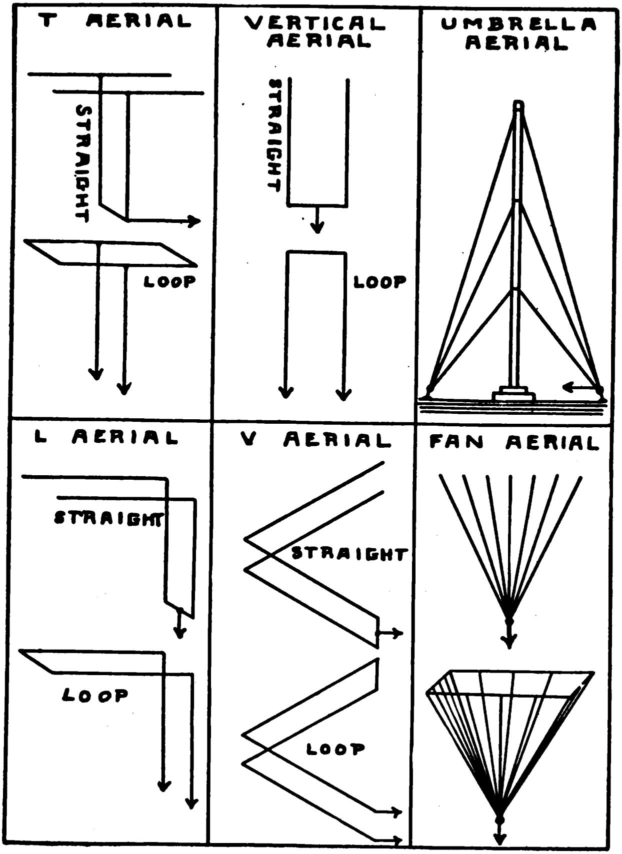
9. Transformer or Spark Coil, Spark Gap, Condenser, 4-Contact Helix, and 3-Point Anchor Gap. For use with loop aerials. As practical as any circuit using a loop aerial.

10. Transformer or Spark Coil, Spark Gap, Condenser, 3-Contact Helix, and 3-Point Anchor Gap. Highly recommended for loop aerials.

11. Transformer or Spark Coil, Spark Gap, Condenser, Oscillation Transformer. The most practical and popular circuit known.

12. Transformer, Spark Gap, three or more Condensers, three or more Oscillation Transformers. A Multiple Transmitting Circuit. For use with very high power.

The best circuits for commercial and long distance work.


T AERIAL
STRAIGHT
LOOP
VERTICAL AERIAL
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UMBRELLA AERIAL
L AERIAL
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V AERIAL
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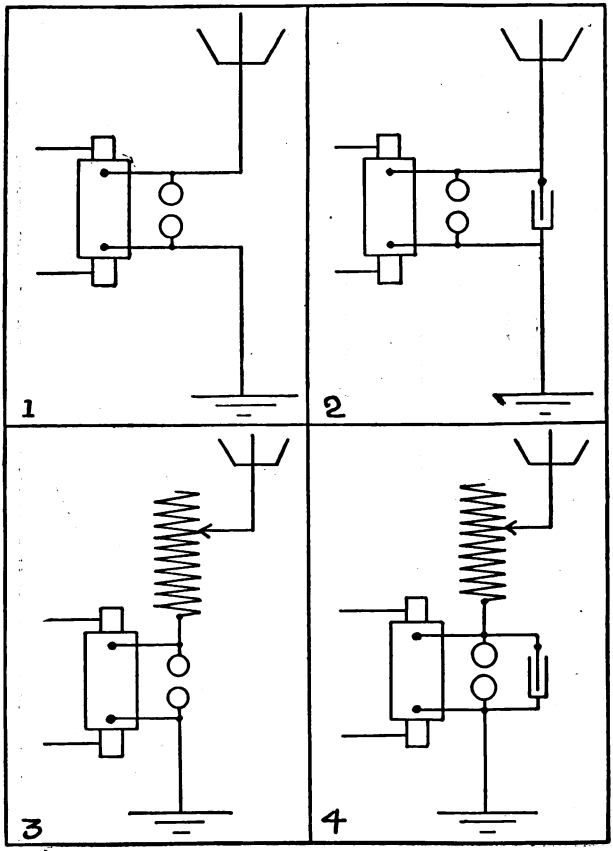
FAN AERIAL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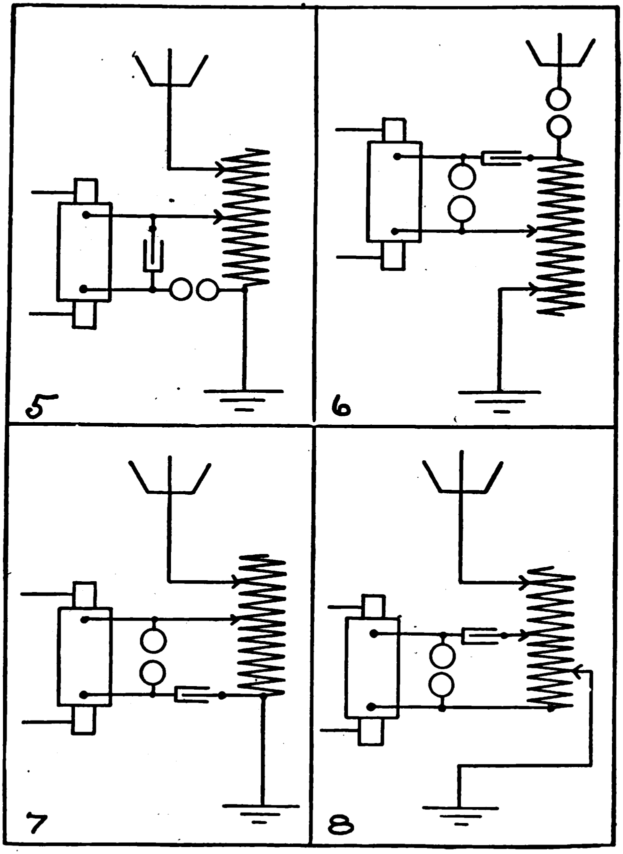
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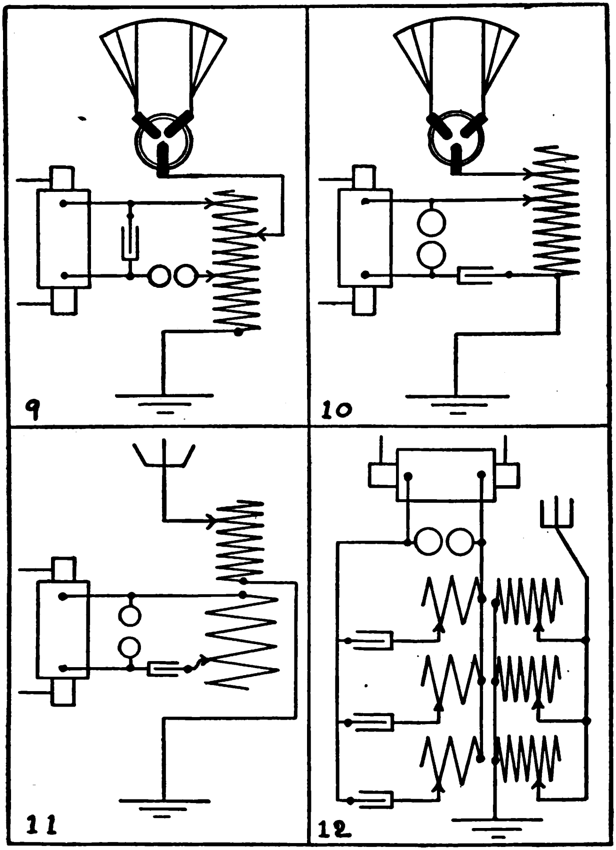
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RECEIVING CIRCUITS. I

SINGLE SLIDE TUNING COILS

1. Tuning Coil, Detector, and Phones. Simplest circuit.

2. Tuning Coil, Fixed Condenser, Variable Condenser, Detector, and Phones. A simple tuned circuit.

3. Tuning Coil, Fixed Condenser, Detector, and Phones. A practical circuit, but subject to interference.

4. Tuning Coil, Fixed Condenser, Detector, and Phones. Practical circuit for the beginner. Fairly selective.

RECEIVING CIRCUITS. II

DOUBLE SLIDE TUNING COILS

5. Tuning Coil, Fixed and Variable Condensers, Detector, and Phones.

6. Tuning Coil, Variable and Fixed Condenser, Detector, and Phones. A practical circuit, but subject to interference.

7. Tuning Coil, Fixed and Variable Condensers, Detector, and Phones. A selective circuit.

8. Tuning Coil, Fixed and Variable Condensers, Detector, and Phones. The most selective 2-slide circuit. Will overcome arc-light interference to a measure.

RECEIVING CIRCUITS. III

THREE SLIDE TUNING COILS

9. Tuning Coil, Fixed and Variable Condensers, Detector, and Phones. An all-around selective circuit.

10. Tuning Coil, Fixed and Variable Condensers, Detector, and Phones. Overcomes arc-light interference.

11. Tuning Coil, Fixed Condenser, two Variable Condensers, Detector, and Phones. Very selective circuit for overcoming static and arc-light interference.

12. Tuning Coil, Fixed and Variable Condensers, Detector, and Phones. The best 3-Slide circuit known. Has auxiliary loose coupling, which has an effect similar to an oscillation transformer. Good for overcoming all kinds of interference.

RECEIVING CIRCUITS. IV

SPLIT AERIAL CIRCUITS

13. Two Single Slide Tuning Coils, two Fixed Condensers, Detector, and Phones. Simple interference preventer.

14. Two Double Slide Tuning Coils, Fixed Condenser, Detector, and Phones. Adapted to overcome the humming of motor and power wires.

15. One Single and one 3-Slide Tuning Coil, Fixed Condenser, two Variable Condensers, Detector, and Phones. Will overcome interference from near-by stations.

16. Two Single Slide Tuning Coils, two Fixed and one Variable Condenser, Detector, and Phones. An all-around interference preventer, and a very popular circuit.

Circuits specially for overcoming different forms of interference.

RECEIVING CIRCUITS. V

LOOP AERIALS

17. Double Slide Tuning Coil, Fixed Condenser, Detector, and Phones. A simple loop circuit.

18. Double Slide Tuning Coil, Fixed and Variable Condensers, Detector, and Phones. A practical circuit for all-around work.

19. Two Double Slide Tuning Coils, two Variable Condensers, Detector, and Phones. For overcoming interference.

20. One Single and one Double Slide Tuning Coil, Fixed and two Variable Condensers, Detector, and Phones. A very selective loop circuit. The best and most popular form.

Loop aerials somewhat less practical than the straight-away forms for general work.

RECEIVING CIRCUITS. VI

LOOSE COUPLED TUNING COILS

21. Loose Coupled Tuning Coil, Fixed Condenser, Detector, and Phones. Simplest circuit.

22. Loose Coupled Tuning Coil, Fixed and Variable Condensers, Detector, and Phones. An extremely selective and sensitive circuit. The most popular circuit.

23. Loose Coupled Tuning Coil, Loading Coil, Fixed and two Variable Condensers, Detector, and Phones. The addition of extra inductance in the circuit, when receiving very long waves. By adding the second Variable Condenser alone, short waves may be tuned in.

24. Loose Coupled Tuning Coil, Single Slide Tuning Coil, Fixed and three Variable Condensers, Detector, and Phones. This is for use in overcoming extreme interference and the humming from high-tension lines.

The best and most practical circuits for commercial and professional use.

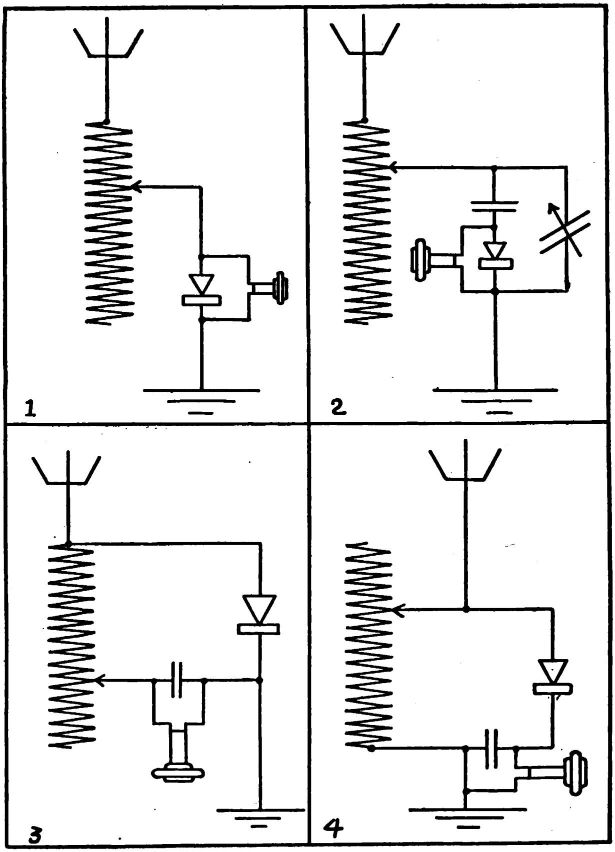
RECEIVING CIRCUITS. VII

25. Loose Coupled Tuning Coil, Fixed and two Variable Condensers, Detector, and Phones. For loop aerials.

26. Loose Coupled and Loading Coil, Fixed and two Variable Condensers, Detector, and Phones. For loop aerials. A practical circuit.

27. Two Loose Coupled Tuning Coils, Loading Coil, Fixed and three Variable Condensers, Detector, and Phones. A weeding-out circuit. Extremely selective, and excellent for overcoming all kinds of interference.

28. Three Loose Coupled Tuning Coils, Loading Coil, Fixed and four Variable Condensers, Detector, and Phones. The tertiary weeding-out circuit. Its selectivity is wonderful, but it is not wholly practical, a slight amount of energy being lost with the addition of each additional loose coupled tuning coil.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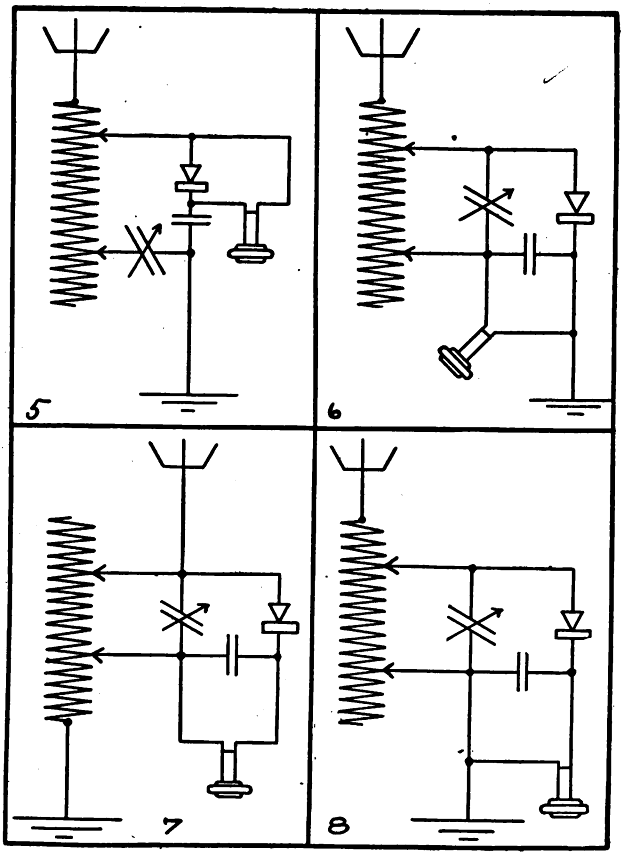
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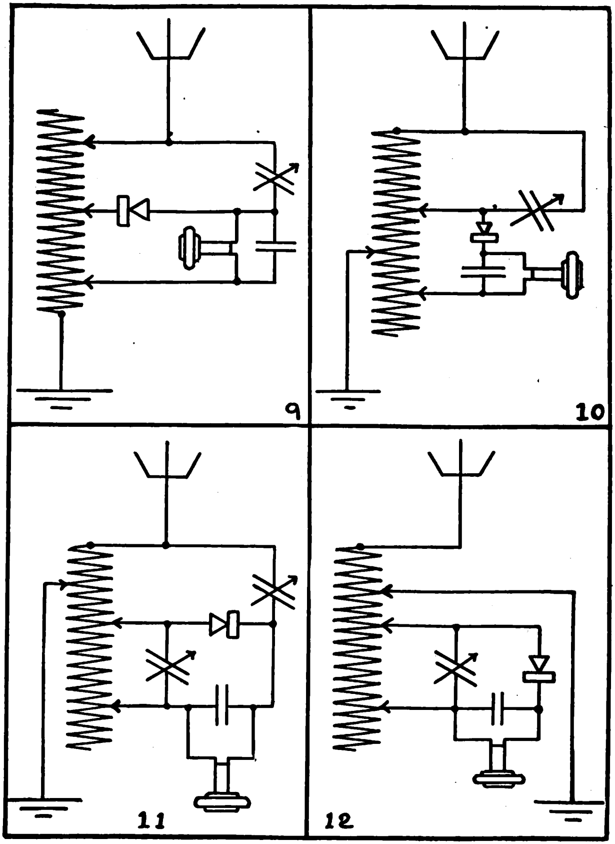
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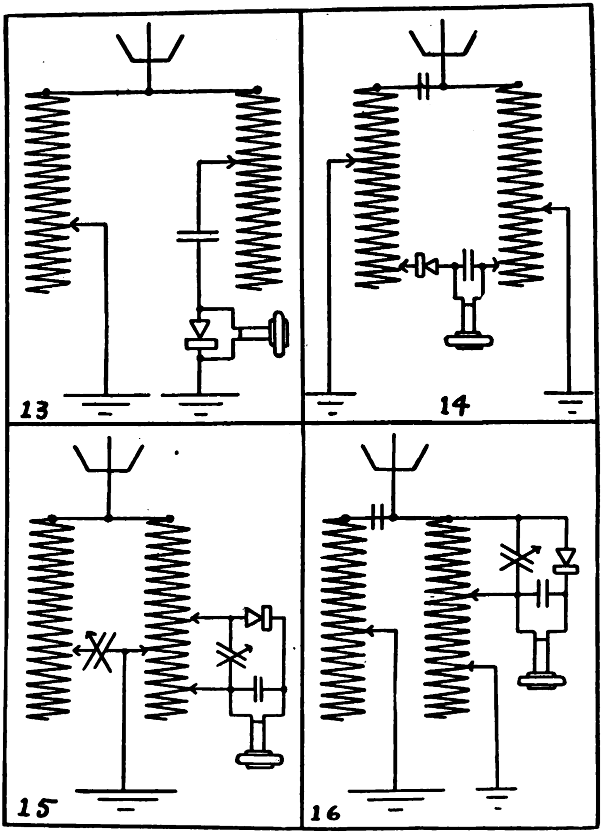
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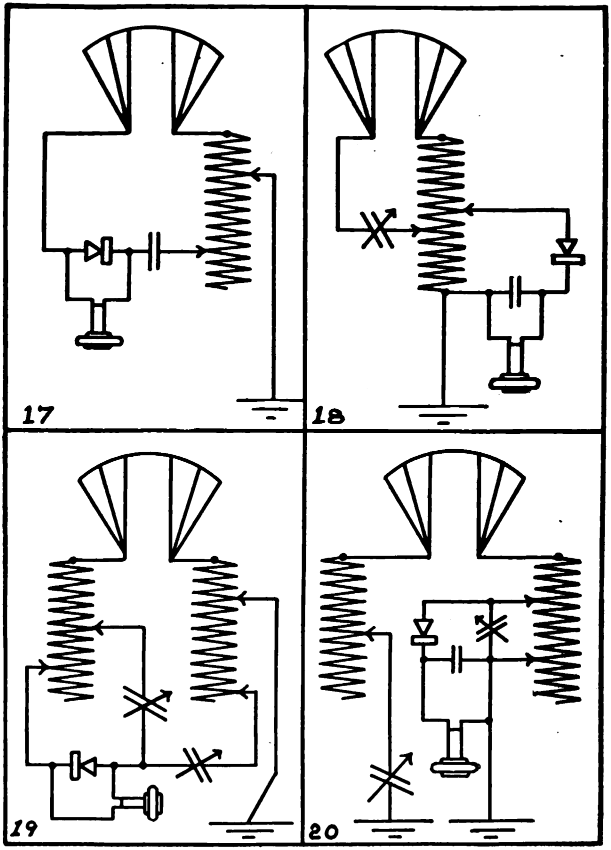
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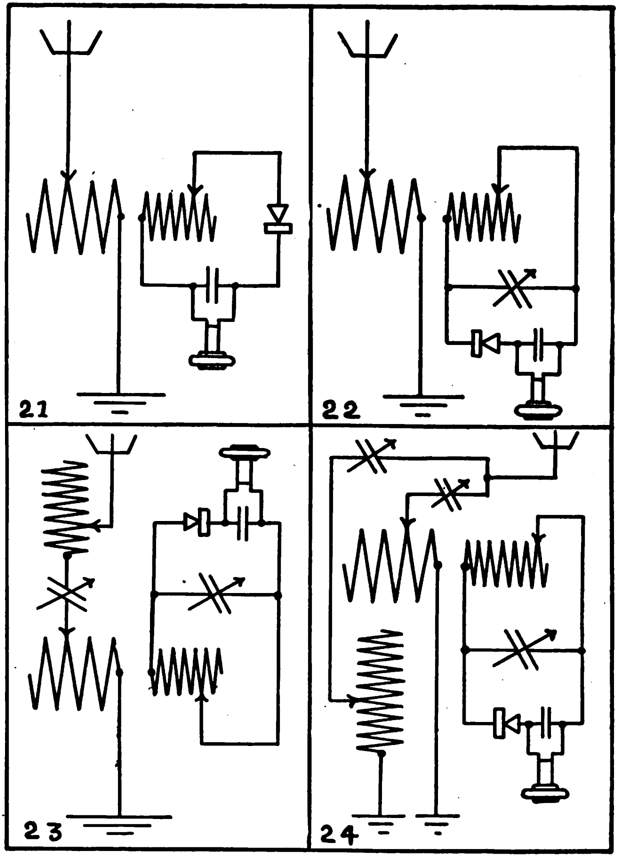
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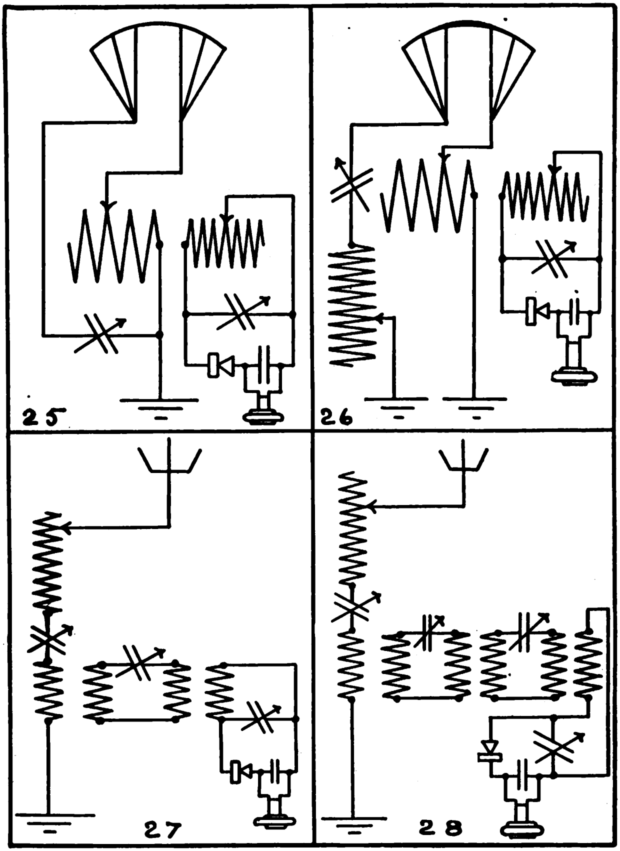
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COMPLETE SETS. I

1. *Transmitting Apparatus:* Spark Coil, Spark Gap, Condenser, and a 1, 2, or 3 Clip Helix. For use with batteries and telegraph key.

Receiving Apparatus: 1, 2, or 3 Slide Tuning Coil, Fixed Condenser, Detector, and Phones. A Variable Condenser may be added.

Switch between Sending and Receiving: S.P.D.T.

A beginner's set.

COMPLETE SETS. II

2. *Transmitting Apparatus:* Spark Coil or Transformer, Spark Gap, Condenser, 3 or 4 Contact Helix. To be run from battery or power, key with durable contacts and adjustable resistance.

Receiving Apparatus: Loose Coupled Tuning Coil, Fixed and Variable Condenser, Detector, and Phones.

Switch between Sending and Receiving: D.P.D.T.

A practical set.

COMPLETE SETS. III

3. *Transmitting Apparatus:* Transformer Spark Gap, Condenser, Sending Oscillation Transformer, two protective devices for the line and transformer, Rheostat or Reactance Regulator, a Key with heavy contacts. A Condenser across the key points to prevent formation of arc between them.

Receiving Apparatus: Loose Coupled Tuning Coil, Fixed and Variable Condensers, Detector, and Phones.

Breaking-in System: Relay with single contact, protective Spark Gap, and Batteries for relay circuit.

Aerial Switch of 100 amperes.

COMPLETE SETS. IV

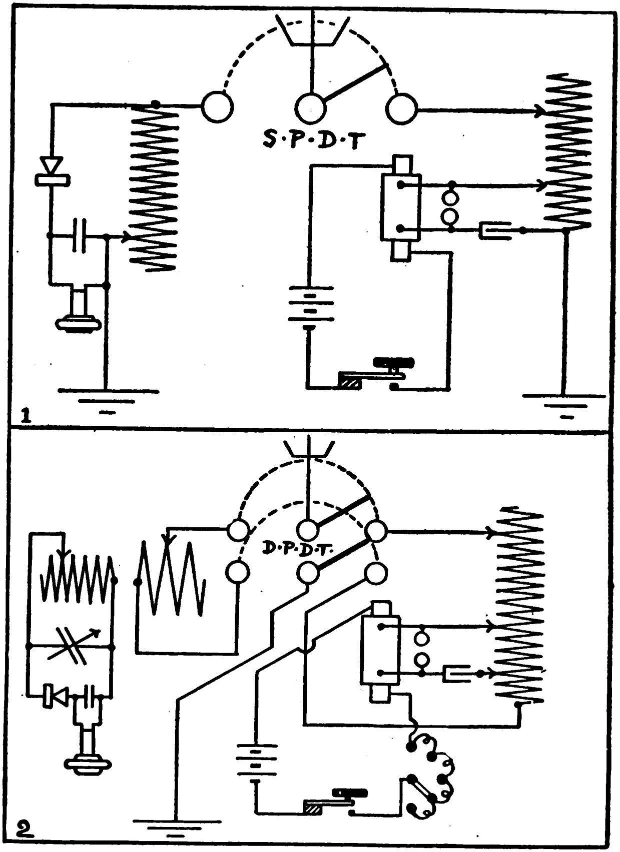
TWO TO FIVE KILOWATT

4. *Transmitting Apparatus:* Transformer, Spark Gap, Condenser, Oscillation Transformer, three protective devices for the transformer, the switchboard, and for the dynamo, a Reactance Regulator, key with heavy contacts with condenser.

Receiving Apparatus: Loose Coupled Tuning Coil, Loading Coil, Fixed and two Variable Condensers, Detector with potentiometer, Battery and Switch, and Phones.

Breaking-in System: Aerial Relay with two contacts, two protective Spark Gaps, Relay with six contacts for protecting the detector, and Batteries.

Switch of 100 amperes.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D·P·D·T.
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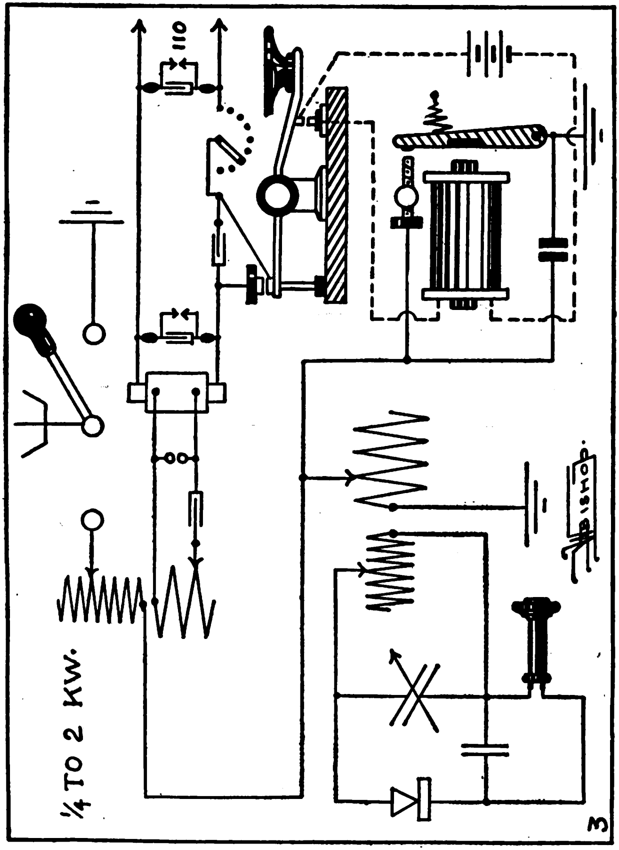
110
¼ TO 2 KW.
BISHOP
3

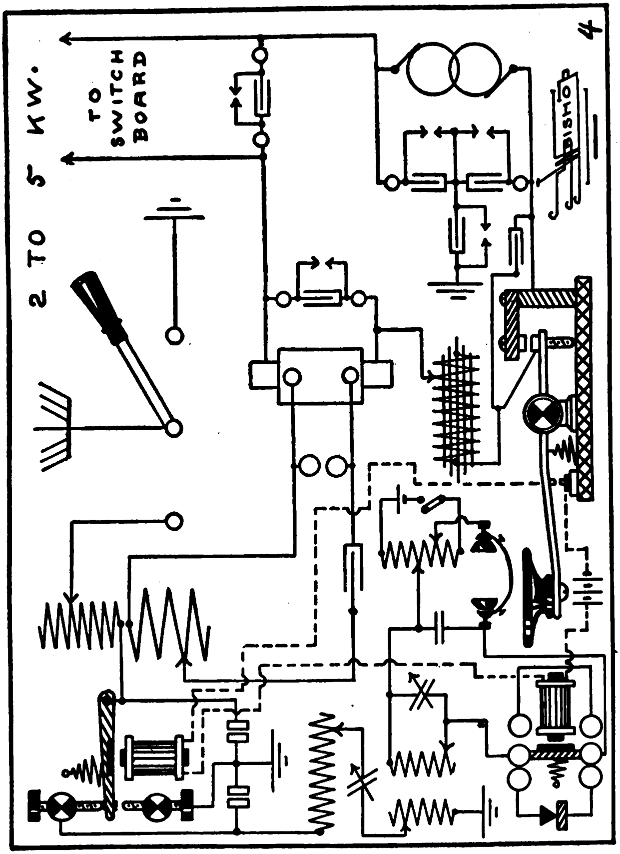
2 TO 5 KW.
TO SWITCH BOARD
4

TABLE OF SENDING AND RECEIVING DISTANCES

In wireless telegraphy the one thing unknown is the distance covered by our instruments. In line telegraphy the distance is regulated by the length of wire. Only the limitations of power limit our transmitting possibilities in wireless; and the degree of sensitiveness shown in our receiving instruments regulates the distances of the stations whose signals we can catch. Every experimenter, indeed every operator, wants to know what those distances are: how far do his signals carry, and how far away is the most distant station whose call he can receive.

Every instrument in the set, its separate quality, influences this distance, and the result must depend somewhat upon personal judgment. However, the author has made tables which may be used roughly to indicate the range of stations consisting of different sorts of apparatus. They will be found pretty nearly adequate in all cases, if the instruments are carefully judged.

A TABLE OF RECEIVING DISTANCES

AERIALS

Position	
Hill (within 10 miles of seacoast)	1
" (30 miles or more inland)	$\frac{4}{5}$
Low land (sea, coast)	$\frac{9}{10}$
" " (clear space, inland)	$\frac{3}{4}$
" " (city or forest)	$\frac{1}{2}$

Type and Value	Vertical Height	Horizontal Length
T L V	$\frac{1}{3}$ in feet	$\frac{1}{10}$ in feet
Umbrella, Fan	$\frac{1}{2}$ " "	$\frac{1}{2}$ spread, in feet
Vertical	$\frac{1}{2}$ " "	

CIRCUIT VALUES

Circuits in back of book as standards

Number	
1, 2, 3, 13	$\frac{2}{5}$
4, 5, 14, 15	$\frac{3}{5}$
6, 16, 17, 18	$\frac{2}{3}$
7, 8, 9, 19	$\frac{7}{10}$
10, 11, 12, 20	$\frac{3}{4}$
25, 26, 27, 28	$\frac{9}{10}$
21, 22, 23, 24	1

DETECTORS AND TELEPHONE RECEIVERS

DOUBLE POLE, ALL COPPER WOUND

Resistance per Pair	Perikon-Elektra	Perikon with Bat.	Perikon No Bat.	Pyron or Ferron	Electro-lytic	Silicon
80	20	12	10	10	8	6
250	22	13	11	11	9	7
500	23	14	12	11	10	8
750	24	14	13	12	11	8
1000	24	15	14	12	11	9
1500	25	15	14	13	12	9
2000	24	15	14	12	11	9
3000	24	16	15	12	10	10

Explanation of Table. Select conditions of the set in question, and multiply their values together to find total receiving distance of station. These distances may be nearly doubled for special atmospheric conditions, and with a good operator. Good between 8 P. M. and 4 A. M. Subtract 20% for day use.

Example

Aerial, Length	180	$\frac{1}{10}$ x 180 = 18
" Height	90	$\frac{1}{3}$ x 90 = 30
Value for Aerial		48
Position, Low, Coast		$\frac{9}{10}$
Circuit, No. 21		1
Detector, Pyron, Phones 1500 ohms		13

48 x $\frac{9}{10}$ x 1 x 13 = 560 miles

SIZES OF AERIAL WIRES

Material	Smallest Size	Largest Size	Kind
Copper	14	8	Stranded or solid
Phosphor bronze	12	6	Stranded or solid
Aluminum	12	6	Solid
Iron (umbrella type)	10	4	Solid

AERIAL INSULATION

Power	Size of Insulators
1 and 2 Inch spark coils	Porcelain cleats or spools
$\frac{1}{4}$ kw. set	2 inch strain insulators
$\frac{1}{2}$ " "	2 " " "
1 " "	6 " " "
2 " "	6 " " "
3 " "	18 " " "
5 " "	18 " " "

A TABLE OF SENDING DISTANCES

Aerials

Must have two or more strands

1. *Position*

On seacoast, high land, clear space	1
On coast, low land	$\frac{3}{4}$

High land, inland	½
Low land, city or forest	¼

1/4

2. *Size*

Height of aerial over 100 feet	1
60–100 foot aerial	¾
40–60 " "	½
30–40 " "	¼

Circuit

3. *Numbers* from chapter on transmitting diagrams

11–12	1
5, 7, 8	¾
6, 9, 10	½
1, 2, 3, 4	⅕

Wave Length

Not under 400 metres

Power

4. *Transformers*

5 kw.	600
4	480
3	420
2½	370
2	300
1½	290
1	240
¾	210
½	180
¼	120
⅛	75

5. *Battery-operated Spark Coils*

50 watts (4 inch spark coil)	40
25 " (2 " " ")	25
15 " (1 " " ")	12
10 " (½ " " ")	8

Explanation of Table. Select the conditions of the set in question, and multiply together to obtain sending distance of the station. These distances may be nearly doubled when atmospheric conditions are especially favorable. A good operator will also improve the distance somewhat.

Example. A station on the coast, but low land; a 100-foot aerial; a good circuit, using a helix; a one 1-kw. transformer.

1 2 3 4 Result, Distance

$\frac{3}{4} \times 1 \times \frac{3}{4} \times 240 = 135$ miles

COMPARISON OF COPPER AND ALUMINUM

	Copper	Aluminum
Specific gravity	8.93	2.68
Conductivity	100	63
Area....................	100	48
Diameter	100	126.04

This shows that aluminum has 63% as great conductivity and 48% of the weight of copper; that for wire of equivalent conductivity it has a cross section 60% greater and a diameter 26.4% greater than copper.

It will be noted from the relative diameters that an aluminum wire of equal conductivity with a copper wire will be almost exactly two sizes larger by the B & S Gauge.

Weight to weight, therefore, the conductivity of aluminum is greater than that of copper by $31\frac{1}{4}\%$

Table of Dimensions and Resistances of Pure Copper Wire.*

REVISED.

No. B. & S.	Resistance at 75°F. R ohms per 1000 feet.	Ohms per mile.	Feet per ohm.	Ohms per pound.	lbs p. 1000 ft. ins'd H.B.&H. line wire.	Feet per lb. ins'd H.B.&H. line wire.
4-0	.04904	.25891	20392.9	.00007653	800	1.25
3-0	.06184	.32649	16172.1	.00012169	666	1.50
00	.07797	.41168	12825.4	.00019438	500	2 00
0	.09827	.51885	10176.4	.00030734	363	2.75
1	.12398	.65460	8066.0	.00048920	313	3.20
2	.15633	.82543	6396.7	.00077784	250	4.00
3	.19714	1.04090	5072.5	.0012370	200	5.00
4	.24858	1.31248	4022.9	.0019666	144	6.9
5	.31346	1.65507	3190.2	.0031273	125	8.0
6	.39528	2.08706	2529.9	.0049728	105	9.5
7	.49845	2.63184	2006.2	.0079078	87	11.5
8	.62849	3.31843	1591.1	.0125719	69	14.5
9	.79242	4.18400	1262.0	.0199853		
10	.99948	5.27726	1000.5	.0317946	50	20.0
11	1.2602	6.65357	793.56	.0505413		
12	1.5890	8.39001	629.32	.0803641	31	32.0
13	2.0037	10.5798	499.06	.127788		
14	2.5266	13.3405	395.79	.203180	22	45.0
15	3.1860	16.8223	313.87	.323079		
16	4.0176	21.2130	248.90	.513737	14	70.0
17	5.0660	26.7485	197.39	.816839		
18	6.3880	33.7285	156.54	1.298764	11	90.0
19	8.0555	42.5329	124.14	2.065312		
20	10.1584	53.6362	98.44	3.284374		
21	12.8088	67.6302	78.07	5.221775		
22	16.1504	85.2743	61.92	8.301819		
23	20.3674	107.540	49.10	13.20312		
24	25.6830	135.606	38.94	20.99405		
25	32.3833	170.984	30.88	33.37780		
26	40.8377	215.623	24.49	53.07946		
27	51.4952	271.895	19.42	84.39916		
28	64.9344	342.854	15.40	134.2005		
29	81.8827	432.341	12.21	213.3973		
30	103.245	545.133	9.686	339.2673		
31	130.176	687.327	7.682	539.3404		
32	164.174	866.837	6.091	857.8498		
33	207.000	1092.96	4.831	1363.786		
34	261.099	1378.60	3.830	2169.776		
35	329.225	1738.31	3.037	3449.770		
36	415.047	2191.45	2.409	5482.766		
37	523.278	2762.91	1.911	8715.030		
38	660.011	3484.86	1.515	13864.51		
39	832.228	4394.16	1.202	22043.92		
40	1049.718	5542.51	.9526	35071.11		

*1 mile pure copper wire 1-16 in. diam.=13.59 ohms at 15.5°C. or 59.9°F.

Table of Dimensions and Resistances of Pure Copper Wire.*

REVISED.

No. B. & S.	Diam. Mils.	Area. Circular Mils.	Area. Square Inches.	W'gt & Length. Sp. gr. 8.9 Lbs. per 1000 ft.	Pounds per mile.	Feet per pound.
0000	460.000	211600.0	166190.2	640.73	3383.04	1.56
000	409.640	167805.0	131793.7	508.12	2682.85	1.97
00	364.800	133079.0	104520.0	402.97	2127.66	2.48
0	324.950	105592.5	82932.2	319.74	1688.20	3.13
1	289.300	83694.5	65733.5	253.43	1338.10	3.95
2	257.630	66373.2	52129.4	200.98	1061.17	4.98
3	229.420	52633.5	41338.3	159.38	841.50	6.28
4	204.310	41742.6	32784.5	126.40	667.38	7.91
5	181.940	33102.2	25998.4	100.23	529.23	9.98
6	162.020	26250.5	20617.1	79.49	419.69	12.58
7	144.280	20816.7	16349.4	63.03	332.82	15.86
8	128.490	16509.7	12966.7	49.99	263.96	20.00
9	114.430	13094.2	10284.2	39.65	209.35	25.22
10	101.890	10381.6	8153.67	31.44	165.98	31.81
11	90.742	8234.11	6467.06	24.93	131.65	40.11
12	80.808	6529.94	5128.60	19.77	104.40	50.58
13	71.961	5178.39	4067.09	15.68	82.792	63.78
14	64.084	4106.76	3225.44	12.44	65.658	80.42
15	57.068	3256.76	2557.85	9.86	52.069	101.40
16	50.820	2582.67	2028.43	7.82	41.292	127.87
17	45.257	2048.20	1608.65	6.20	32.746	161.24
18	40.303	1624.33	1275.75	4.92	25.970	203.31
19	35.890	1288.09	1011.66	3.90	20 594	256.89
20	31.961	1021.44	802.24	3.09	16.331	323.32
21	28.462	810.09	636.24	2.45	12.952	407.67
22	25.347	642.47	504.60	1.95	10.272	514.03
23	22.571	509.45	400.12	1.54	8.1450	648.25
24	20.100	404.01	317.31	1.22	6.4593	817.43
25	17.900	320.41	251.65	.97	5.1227	1030.71
26	15.940	254.08	199.56	.77	4.0623	1299.77
27	14.195	201.50	158.26	.61	3.2215	1638.97
28	12.641	159.80	125.50	.48	2.5548	2066.71
29	11.257	126.72	99.526	.38	2.0260	2606.13
30	10.025	100.50	78.933	.30	1.6068	3286.04
31	8.928	79.71	62.603	.24	1.2744	4143.18
32	7.950	63.20	49.639	.19	1.0105	5225.26
33	7.080	50.13	39.369	.15	.8014	6588.33
34	6.304	39.74	31.212	.12	.6354	8310.17
35	5.614	31.52	24.753	.10	.5039	10478.46
36	5.000	25.00	19.635	.08	.3997	13209.98
37	4.453	19.83	15.574	.06	.3170	16654.70
38	3.965	15.72	12.347	.05	.2513	21006.60
39	3.531	12.47	9.7923	.04	.1993	26427.83
40	3.144	9.88	7.7365	.03	.1580	33410.05

***1 mile pure copper wire 1-16 in. diam.=13.59 ohms at 15.5°C or 59.9°F.**

TABLE OF WIRE "B. AND S." GAUGE.

GAUGE.	Diam. in $\frac{1}{1000}$ inch.	Area in Circ. Mills. $A=D^2$	Lbs. per ft. bare.	Lbs. per ft. covered.	Resist'n'c in ohms. per foot.	Cents per Foot Covered,		
						At 16c. lb.	At 18c. lb.	At 20c. lb.
0000	.460	211600	.639	.821	.0000491	.1814	.1478	.1642
000	.410	167805	.507	.619	.0000619	.099	.1114	.1238
00	.365	133079	.402	.441	.000078	.0706	.0794	.0882
0	.325	105592	.319	.356	.0000983	.057	.0641	.0712
1	.289	83694	.253	.284	.000124	.0454	.0511	.0568
2	.258	66373	.201	.235	.0001564	.0376	.0423	.0470
3	.229	52634	.159	.191	.0001973	.0306	.0344	.0382
4	.204	41742	.126	.158	.0002487	.0253	.0284	.0316
5	.182	33102	.1	.127	.0003136	.0203	.0229	.0254
6	.162	26250	.079	.102	.0003955	.0163	.0184	.0204
7	.144	20816	.063	.085	.0004987	.0136	.0153	.017
8	.128	16509	.05	.069	.0006288	.011	.0124	.0138
9	.114	13094	.04	.054	.0007928	.0086	.0097	.0108
10	.102	10381	.031	.047	.001	.0075	.0085	.0094
11	.091	8234	.025	.036	.0012607	.0058	.0065	.0072
12	.081	6530	.02	.031	.0015898	.005	.0056	.0062
13	.072	5178	.016	.026	.0020047	.0042	.0047	.0052
14	.064	4107	.012	.02	.0025908	.0033	.0036	.004

SUPPLEMENT

TO THE

Wireless Operators' Pocket-book

OF

Information and Diagrams

BY

LEON W. BISHOP

LATEST CALL LIST OF WIRELESS STATIONS

ALPHABETICALLY ARRANGED

1911

BUBIER PUBLISHING COMPANY
LYNN, MASS., U.S.A.

WIRELESS OPERATORS' POCKET-BOOK

OF

Information and Diagrams

SUPPLEMENT

LATEST CALL LIST OF STATIONS

Isles of Shoals, N.H.	A
S. S. Alabama	AB
S. S. Sabine	AB
S. S. Chicago	AB
S. S. Aberdeen	ABD
S. S. Concho	AC
S. S. Denver	AD
S. S. Victoria	AD
Amsterdam, Holland	ADM
S. S. Colorado	AF
S. S. Rio Grande	AG
S. S. Yucatan	AG
S. S. Nueces	AH
S. S. Pennsylvania	AH
S. S. Alamo	AJ
German pilot steamer Jade	AJA
S. S. San Marcos	AK
S. S. Santa Clara	AK
S. S. Loftus Cuddy	AL
Algiers, Algeria	ALG
Almeria, Spain	ALM
S. S. America	AM
S. S. Comal	AM
S. S. Riverside	AM
Kamalo, Molokai, Hawaiian Islands	AM
S. S. Northwestern	AN
Antivari, Montenegro	AN
S. S. Minda	AND
S. S. Ohio	AO
S. S. Lampasas	AP
S. S. City of Benton Harbor	AQ
S. S. Roanoke	AQ
S. S. San Jacinto	AS
S. S. Admiral Sampson	AS
Amsterdam navy-yard	ASD
U. S. Army transport Buford	ATB
U. S. Army transport Dix	ATD
U. S. Army transport Sumner	ATH
U. S. Army transport Kilpatrick	ATK
U. S. Army transport Logan	ATL
U. S. Army transport Sherman	ATR
U. S. Army transport Sheridan	ATS
U. S. Army transport Thomas	ATU
S. S. Dolphin	AU
Chatham, Mass.	AU
S. S. Seward	AV
S. S. Olympia	AW
S. S. Kansas City	AX
Atlantic City, N.J.	AX
S. S. Geo. W. Elder	AY
S. S. Brazos	AZ
Avalon, Catalina Island, Cal.	A2
Tug Tyee	A3
Baltimore, Md. (American Building)	B
Bocas del Toro, Panama	B

S. S. Bermudian	BA
Buenos Aires, Argentine Republic	BA
Batavia, Dutch East Indies	BA
Abo, Russia	BAO
S. S. Batavier IV	BBF
S. S. Batavier II	BBS
S. S. Batavier III	BBT
S. S. Batavier V	BBV
S. S. Virginia	BC
S. S. W. S. Porter	BD
S. S. Trinidad	BD
New York, N.Y.	BD
Buffalo, N.Y. (News Building)	BF
Philadelphia, Pa.	BF
Bridgeport, Conn.	BG
S. S. Iroquois	BG
Helsingfors. Finland	BGF
Quincy, Mass.	BH
S. S. Chippewa	BH
Benton Harbor, Mich.	BH
Blaavands Huk, Denmark	BH
S. S. Indianapolis	BI
S. S. John J. Barlum	BJ
Leckte, Russia	BLH
Libau, Russia	BLW
S. S. Nyack	BM
S. S. Boston	BN
S. S. Rosecrans	BN
Nikolaistadt, Russia	BNCh
S. S. Nann Smith	BO
Brant, Rock Mass.	BO
S. S. Hermosa	BP
Preste, Russia	BPS
S. S. Bruce	BR
S. S. Thomas Barlum	BR
Britz, Germany	BR
Overtoom, Holland	BRBR
Reval, Russia	BRW
Philadelphia, Pa. (Bellevue-Stratford)	BS
Washington, D.C., Bureau of Standards	BS
U. S. Army cableship Burnside	BS
Sevastapol, Russia	BSP
S. S. Nyades	BT
Butt of Lewis, Scotland	BTL
S. S. Rupert City	BU
S. S. Cabrillo	BV
S. S. Alliance	BW
Vladivostok, Siberia	BWT
S. S. City of South Haven	BX
Shoeburyness, England	BY
Babylonia, Brazil	BYN
Bombay, India	BYR
Bessemer Barge No. 2	B2
Tug Goliah	B3
Camaguey, Cuba	C
S. S. City of Alpena	CA
S. S. Coamo	CA
S. S. Priscilla	CA
Cambridge, England	CA
Saginaw, Mich.	CAN
S. S. Ashtabula	CAR
S. S. Regele Carol I	CAR
S. S. Carolina	CB
Buffalo, N.Y.	CB
Boca del Colorado, Costa Rica	CB
Cheribon, Dutch East Indies	CB
S. S. Sierra	CBJ
S. S. City of Cleveland	CC
S. S. City of Detroit	CD
Duluth, Minn.	CD
Clifden, Ireland	CDN
Detroit, Mich.	CF
Chicago, Ill	CG
Cape May, N.J.	CG

S. S. City of St. Ignace	CG
Charlottenburg, Germany	CG
S. S. Quadra	CGS
Port Huron, Mich.	CH
San Franciso, Cal. (Chronicle	CH
Chamartin, Spain	CH
S. S. Harmonic	CHA
S. S. Huronic	CHN
Erie, Pa.	CI
Sault Ste. Marie, Mich.	CJ
S. S. San Juan	CJ
S. S. Juanita	CJA
Detroit, Mich. (Detroit Journal)	CJL
S. S. Charlois	CLS
Calumet, Mich.	CM
Milwaukee, Wis.	CM
Buenos Aires, Argentine Republic	CM
S. S. Hugh Kennedy	CMA
S. S. Jos. Sellewood	CMB
S. S. S. M. Clement	CMD
S. S. Pendenis White	CMF
S. S. Moses Taylor	CMG
S. S. James Gayley	CMH
S. S. W. H. Gratwick	CMI
S. S. J. J, Albright	CMJ
S. S. Walter Scranton	CMK
S. S. E. A. S. Clarke	CMN
S S. Wm. E. Reis	CMP
S. S. N. A. Hanna	CMQ
S. S. H. S.Houlden	CMR
S. S. Lagonda	CMS
S. S. J. J. McWilliams	CMU
S. S. Major	CMV
S. S. Robt. L. Fryer	CMW
Bishop, Boston, Mass.	CN
Cleveland, Ohio	CN
Ashtabula, Ohio	CO
Cayo Criso, Cuba	CO
Coruna, Italy	CO
Marion, Mass.	CON
Corvo, Azores	COR
S. S. Ponce	CP
Port Arthur, Ontario	CPA
S. S. Princess Charlotte	CPC
S. S. Princess May	CPM
S. S. Princess Royal	CPR
Tug Tees	CPT
S. S. Princess Victoria	CPV
Marquette, Mich.	CQ
S. S. City of Erie	CR
S. S. Senaca	CS
S. S. Eastern States	CS
St. Thomas, Ontario	CST
S. S. Canada	CT
Toledo, Ohio	CT
S. S. Tionesta	CTA
S. S. City of Buffalo	CU
S. S. Commonwealth	CW
S. S. Western States	CW
Detroit, Mich.	CW
S. S. St. Croix	CX
Cleveland, Ohio	CX
Bay City, Mich.	CY
Seattle, Wash. (Hotel Perry)	DA
Santa Clara, Cuba	DA
S. S. Philadelphia	DA
S. S. Admiral	DAA
S. S. Augustus B. Wolvin	DAB
S. S. Burgomaster	DAB
S. S. Dacia	DAC
S. S. Field Marshal	DAF
S. S. Adeline	DAH
S. S. Anni	DAI
S. S. Kronprinz	DAK
S. S. James H. Hoyt	DAM
S. S. Frank H. Peavey	DAN
S. S. Neubau	DAN
S. S. Prinz Regent	DAP

S. S. Adolf Woermann DAW
S. S. Prinzessin DAZ
Tacoma, Wash. DB
S. S. Caracas DB
American schooner Dorothy B. Barrett DBB
S. S. Birkenfels DBB
Durban, Hatal DBN
S. S. Bremen DBR
S. S. Bulow DBW
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S. S. Iowa DC
S. S. Cap Arcona DCA
S. S. Cap Blanco DCB
S. S. Cap Verde DCE
S. S. Cap Frio DCF
S. S. Tietgen DCF
S. S. Clare DCH
S. S. Kronprinzessin Cecile DCI
S. S. Clara Blumenfeld DCL
S. S. Cap Ortegal DCO
S. S. Cap Roca DCR
S. S. Cap Vilabo DCV
S. S. Kaiserin Augusta Victoria DDA
S. S. Bleucher DDB
S. S. Cincinnati DDC
S. S. Bulgaria DDG
S. S. Pisa DDF
S. S. Hamburg DDH
S. S. President Lincoln DDI
S S. Batavia DDJ
S. S. Deutschland DDL
S S. Moltke DDM
S. S. Pennsylvania DDN
S. S. Prinz Oscar DDO
S. S. Patricia DDP
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S. S. Amerika DDR
S. S. President Grant DDS
S. S. Pretoria DDT
S. S. Cleveland DDV
S. S. Graf Waldersee DDW
S. S. Prinz Adalbert DDZ
Pasadena, Cal. DE
S. S. Edmund DEH
S. S. Derfflinger DER
S. S. Elenore Woermann DEW
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Vancouver, British Columbia DF
S. S. Furst Bismarck DFB
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S. S. Camerones DHC
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S. S. Hohenstauffen DHN
S. S. Frank T. Heffelinger DHN
S. S. Hellig Olav DHO
S. S. Presidente de Mintre DHP
S. S. Presidente Quintana DHQ
S. S. Holger DHR
S. S. Kingsway DI
S. S. Imperator DIR

San Pedro, Cal. DJ
S. S. James C. Wallace DJC
S. S. James H. Reed DJR
Everett, Wash. DK
S. S. Kronprinzessin Cecile DKA
S. S. Berlin DKB
Ikeda Head, Wash. DKD
S. S. Friedrich der Grosse DKD
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S. S. Konig Friedrich August DKF
S. S. Konig Wilhelm II DKG
S. S. Grosser Kurfurst DKG
S. S. Main DKI
S. S. Neckar DKK
S S. Konigen Luise DKL
S. S. Kaiser Wilhelm II DK
S. S. George Washington DKN
S. S. Konig Albert DKO
S. S. Kronprinz Wilhelm DKP
S. S. Rhein DKR
S. S. Barbarossa DKS
S. S. Kaiser Wilhelm der Grosse DKW
S. S. Princess Alice DKZ
S. S. Lutzow DLO
S. S. Lucile Woermann DLW
Duluth, Minn. DM
S S. Meteor DMR
S. S. Mainz DMZ
San Luis Obispo, Cal. DN
Drogden, Denmark DN
S. S. Nora DNH
S. S. Moskwa DOA
S. S. Oscar second DOR
Dieppe, France DP
S. S. Prince Adalbert DPA
S. S. Prinz Eitel Friedrich DPE
S. S. Prinz Ludwig DPL
S. S. Prince Sigismund DPS
S. S. Prince Waldemar DPW
Eugene, Oreg. DR
Detroit, Mich. DR
S. S. Corcovado DRC
S. S. Prinz Regent Luitpold DRL
S. S. Roon DRN
South Haven, Mich. DS
Port Townsend, Wash DS
S. S. Scharnhorst DSA
S. S. Senator Holthusen DSH
S. S. Sarnia DSM
S. S. H. P. Bope DSO
S. S. Senator Refardt DSR
S. S. Kleist DST
S. S. Siberia DSV
S. S. Seyditz DSZ
S. S. Titania DTG
S. S. Admiral DTP
Wilmington, Del. DU
Juneau, Alaska DU
S. S. Geo. W. Peavey DUF
S. S. United States DUS
Chehalis, Wash. DV
Newport, Oreg. DW
S. S. Ward Ames DWA
Toledo, Ohio (Hotel Secor) DX
S. S. Ypiranga DYA
S. S. Yorck DYK
Lansing, Mich. DZ
Portland, Oreg. DZ
S. S. Ziethan DZN
American schooner Pendleton Sisters D1
Port Townsend, Wash. D2

S. S. Earl Grey	EG
S. S. El Norte	EN
S. S. Easton	ES
Cerritos de Sinaloa, Mexico	EY
U. S. Army cable boat Field	FA
S. S. City of Columbus	FA
Malabang, P. I.	FA
Fayal. Azores	FAL
Outer Jade lightship, Germany	FAU
S. S. City of Atlanta	FB
Fairbanks, Alaska	FB
Borkum Reef lightship, Germany	FBR
Fort Andrews, Mass.	FC
S. S. City of Macon	FC
Fort Wood, N. Y.	FD
S. S. City of Memphis	FD
Nome, Alaska	FD
Ferrol, Spain	FE
Kotlik, Alaska	FE
Elbe I lightship, Germany	FEF
S. S. Naomi	FG
Fort Gibbon, Alaska	FG
Corregidor Island, P. I.	FH
Eider lightship, Germany	FIF
S. S. City of Augusta	FJ
Fort Stevens, Oreg.	FJ
S. S. City of Savannah	FK
Circle City, Alaska	FK
Fort Leavenworth, Kans.	FL
Flores, Azores	FLO
Flekkero, Norway	FLK
Fort St. Michael, Alaska	FM
Fort Morgan, Ala.	FM
Zamboanga, P. I.	FM
Fort Hancock, N. J.	FN
Flannon, Isle, Scotland	FNL
Fastnet, Ireland	FNT
Fort Monroe, Va.	FO
S. S. Nacoochee	EP
Petersburg, Alaska	FP
Fort Egbert, Alaska	FQ
U. S. Army Cable Ship Joseph Henry	FR
Fort Omaha, Nebr.	FS
Jolo, P. I.	FS
Fort Totten, N. Y.	FT
Fort Levett, Me.	FV
Villegignon, Brazil	FVG
Fort H. G. Wright, N.Y.	FW
Wrangell, Alaska	FW
Wesser lightship, Germany	FWF
S. S. City of St. Louis	FX
Fort Worden, Wash.	FX
S. S. City of Montgomery	FY
U. S. Artillery harbor tug, General R. B. Ayres	FY
Yacht Lydonia	FZ
Fort Riley, Kans.	FZ
S. S. City of Seattle	GA
S. S. Capt. A. F. Lucas	CB
Cape Breton, Glace Bay, Nova Scotia	GB
Bolt Head, England	GBA
S. S. Georgia	GC
Brow Head, Ireland	GCK
Caistor, England	GCS
Standard Oil barge 91	GD
Graady lightship, Denmark	GD
S. S. City of Everett	GF
S. S. Falcon	GF
S. S. Maverick	GH
Grand Haven, Mich.	GH
Gjedser, Denmark	GJ
S. S. Cottage City	GK
Standard Oil barge 94	GK
Karlskrona, Sweden	GK

The Lizard, England	GLD
Liverpool, England	GLV
Grand Marians, Minn.	GM
S. S. Asuncion	GM
S. S. Pilgrim	GM
Malin Head, Ireland	GMH
S. S. Atlas	GN
North Foreland, England	GNF
Niton, England	GNI
Chicago, Ill. (Congress Hotel)	GO
Standard Oil barge 95	GP
S. S. City of Pueblo	GQ
Copenhagen, Denmark	GRA
Guaraliba, Brazil	GRA
Rosslare, Ireland	GRL
Grand Rapids, Mich.	GRM
S. S. Astral	GS
S. S. Senator	GS
S. S. Umatilla	GU
Guernsey, England	GU
Guadalajara, Spain	GU
Galveston, Texas	GV
S. S. Governor	GV
Grand Island, La.	GW
S. S. President	GW
S. S. Queen	GX
Los Angeles, Cal.	G2
Holland, Mich.	H
Horten, Norway	H
Cape Hatteras, N. C.	HA
New Orleans, La. (United Fruit Co.)	HB
U. S. Army Artillery harbor tug Harvey Brown	HB
Heysham, England	HBR
S. S. Arizona	HC
Carlobago, Austria-Hungary	HC
S. S. Alameda	HD
Elizabeth City, N.C.	HD
Helder, Holland	HDR
Fiume, Austria-Hungary	HF
S. S. Mariposa	HK
New Orleans, La.	HK
Cape d'Aguilar, Hongkong	HK
Haaks Lightship, Holland	HKS
S. S. Jefferson	HM
S. S. Hanalia	HN
S. S. Chester W. Chapin	HN
S. S. Missouri	HN
Hunstanton, England	HNU
S. S. Corwin	HO
S. S. Chicago	HO
Hoek van Holland	HOK
Trinidad (High Post)	HP
Mackinac Island, Mich.	HQ
Horns Reef lightship, Denmark	HR
Cabo Haro, Mexico	HR
Tug Savage	HS
S. S. Londonderry	HSM
Nak Nek, Alaska	HT
Kahuku, Oahu, Hawaiian Islands	HU
Havana, Cuba (Vedado)	HV
S. S. Grant	HV
S. S. Mackinaw	HW
Cuban Revenue Cutter Hatuey	HY
Ludington, Mich.	HX
S. S. Humboldt	HX
Amesbury, Mass	HY
S. S. Plymouth	HY
Zengg, Austria-Hungary	HZ
S. S. Rose City	H2
Brest, France (arsenal)	IBF
Ilha das Cobras, Brazil	ICL
Inistrahull, Ireland	IH
S. S. Illinois	IN
Toulon, France	ITF

S. S. Imparatul Traian	ITR
Port Vendres, France	IVF
S. S. City of Racine	JC
Kingston, Jamaica	JCA
Chosi, Japan	JCS
S. S. North Land	JD
Jersey, England	JE
S. S. Horato Hall	JH
S. S. Manhattan	JM
Otchishi, Japan	JOI
Ose Saki, Japan	JOS
S. S. North Star	JS
Shiomizaki, Japan	JSM
Tsunoshima, Japan	JTS
S. S. James Whalen	JW
Jacksonville, Fla.	JX
S. S. Antilles	KA
Puako, Hawaiian Islands	KA
Angaur, Caroline Islands	KAN
Spokane, Wash.	KB
Bremerhaven, Lloyd Hall, Germany	KBH
Arkona, Germany	KAR
Bwlk, Germany	KBK
Borkum, Germany	KBM
Brunsbuttelkoog, Germany	KBR
S. S. Christopher Columbus	KC
Cuxhaven, Germany	KCX
S. S. Comus	KD
St. Helens. Oreg,	KE
S. S. King Harold	KGH
Helgoland, Germany	KHG
Yap, Caroline Islands	KJA
S. S. Momus	KM
Marienleuchte, Germany	KMR
Erie, Pa.	KN
Norddeich, Germany	KND
Pachena Point, British Columbia	KPD
S. S. Creole	KR
S. S. Santa Cruz	KS
Constanca, Roumania	KST
The Dalles, Oreg.	KT
Tsingtau, China	KTS
Signalberg, Germany	KTS
Walla Walla, Wash.	KU
Key West, Fla.	KW
S. S. Kentucky	KY
Lahaina, Maui, Hawaiian Islands	LH
Machrihanish Bay, Scotland	LK(D)
Cullercoats, England	LNS
S. S. Lady Laurier	LR
Castelneuvo, Austria-Hungary	LRC
Pola, Austria-Hungary	LRP
Sebenico, Austria-Hungary	LRS
Loch Boisdale, Scotland	LSG
Lussin, Austria-Hungary	LU
Havana, Cuba. (Morro Castle)	M
Messina, Italy	M
S. S. Alliance	MA
S. S. Maine	MA
S. S. Carmania	MAA
S. S. Lombardia	MAB
S. S. Sicilia	MAC
S. S. Duca Degli Abruzzi	MAD
S. S. Duca di Genova	MAE
S. S. Mendoza	MAF
S. S. Cordova	MAG
S. S. Virginia	MAH
S. S. Caledonia	MAI
S. S. Indiana	MAK
S. S. Liguria	MAL
S. S. Lusiania	MAM

S. S. Niagara	MAN
S. S. Duca d'Aosta	MAO
S. S. Sardegna	MAS
Steam yacht Atalanta	MAT
American Tickle, Labrador	MAT
Asinara, Sardinia, Italy	MAS
S. S. Umbria	MAU
S. S. Florida	MAV
S. S. Alva	MAV
S. S. Antony	MAY
Mobile, Alá.	MB
Cable steamer Mackay-Bennett	MB
S. S. Asturias	MBB
S. S. Baltic	MBC
Bardèra, Italy	MBD
Cape Bear, Prince Edward Island	MBE
S. S. Araguay	MBG
Battle Harbor, Labrador	MBH
Belle Isle, Newfoundland	MBI
Bernal, Argentine Republic	MBL
S. S. Arragon	MBN
S. S. Avon	MBO
S. S. Ben My Chree	MBQ
Bloomfield, England	MBR
Palm Beach, Fla.	MBS
Becco di Vela, Caprera, Italy	MBV
S. S. Athenie	MBW
Brava, Italy	MBW
S. S. Old Colony	MC
S. S. Sheboygan	MC
S. S. Campania	MCA
Chateau Bay, Labrador	MCB
Cape Cod, Mass.	MCC
Steam yacht Cassandra	MCD
S. S. Cambria	MCG
Mocangue, Brazil	MCG
S. S. California	MCI
Point Rich, Nova Scotia	MCH
S. S. Chili	MCI
Clarke City, Seven Islands, Canada	MCK
Cable ship Colonia	MCL
Capo Mele, Liguria, Italy	MCM
S. S. Corsican	MCN
S. S. Chaco	MCO
Monte Capuccini, Ancona, Italy	MCP
Cape Ray, Newfoundland	MCR
S. S. Bucaneer	MCT
Cape May, N. J.	MCY
Cozzo Spadaro, Cape Passaro, Sicily	MCZ
S. S. Cristobal	MD
S. S. Shinnecock	MD
S. S. Cedric	MDC
S. S. Dominion	MDF
S. S. Devonian	MDL
S. S. Sardinian	MDN
Domino Island, Labrador	MDO
Steam yacht Electra	ME
S. S. Etruria	MEA
S. S. Tamarac	MEB
S. S. Narragansett	MEC
S. S. Cassandra	MED
S. S. Iroquois	MEI
Merka, Italy	MEK
S. S. Bohemian	MEL
Melilla, Morocco	MEL
S. S. Navahoe	MEN
S. S. Empress Queen	MEQ
S. S. Royal Edward	MER
S. S. Satrustegin	MES
S. S. Alfonse XII	MET

S. S. Finance	MF
S. S. Lusitania	MFA
S. S. Arabic	MFC
S. S. Canada	MFC
S. S. Finland	MFD
S. S. W. H. Gratwick	MFD
Fraserburgh, Scotland	MFH
S. S. Furnessia	MFI
S. S. Winifredian	MFL
S. S. Pretorian	MFN
Fame Point, Quebec	MFP
Fort Spuria, Messina, Italy	MFS
Tug Tatoosh	MG
S. S. Mauretania	MGA
Steam yacht Lysistrata	MGB
S. S. Cymric	MGC
S. S. Saturnia	MGD
S. S. Germania	MGE
S. S. Harvard	MGH
Grosse Isle, Quebec	MGI
S. S. Canadian	MGL
S. S. Virginian	MGN
Giumbo, Italy	MGO
S. S. Royal George	MGR
S. S. Yale	MGY
S. S. Panama	MH
S. S. Noordan	MHA
S. S. New Amsterdam	MHB
S. S. Adriatic	MHC
New Haven, England	MHH
S. S. Cestrian	MHL
S. S. Potsdam	MHM
S. S. Cartheginian	MHN
Heath Point, Anticosti Island, Canada	MHP
S. S. Rotterdam	MHR
S. S. Statendam	MHS
Camperdown, Halifax, Nova Scotia	MHX
S. S. Rijndam	MHY
S. S. Minnesota	MI
S. S. Ivernia	MIA
S. S. Laurentic	MIC
S. S. Inanda	MID
S. S. Inkosi	MIK
S. S. Iolanda	MIL
S. S. Principesa Mafalda	MIM
S. S. Ionian	MIN
S. S. Principesa Iolanda	MIO
Itala, Italy	MIT
S. S. Suevic	MJC
S. S. Haverford	MJH
S. S. Merion	MJM
S. S. Millinocket	MK
Milwaukee, Wis.	MK
S. S. Olympic	MKC
S. S. Kroonland	MKD
S. S. Frisia	MKF
S. S. Holland	MKH
S. S. Corinthian	MKN
S. S. Makura	MKU
S. S. Killarney	MKY
S. S. Montcalm	ML
S. S. Guadeloupe	MLA
S. S. La Bretagne	MLB
S. S. Celtic	MLC
S. S. Leopold II	MLD
S. S. Lake Erie	MLE
S. S. Milwaukee	MLF
S. S. La Flandre	MLF
S. S. La Gascoyne	MLG
S. S. Lake Michigan	MLH
S. S. Montreal	MLI
S. S. Montrose	MLJ
S. S. Montezuma	MLK
S. S. La Lorraine	MLL
S. S. Lake Manitoba	MLM
S. S. Lake Champlain	MLN
S. S. Mount Royal	MLO
S. S. La Provence	MLP
S. S. Mount Temple	MLQ
S. S. La Navarre	MLR
S. S. La Savoie	MLS

S. S. La Touraine	MLT
S. S. La Champagne	MLU
Lugh, Italy	MLU
S. S. Montfort	MLW
S. S. Monmouth	MLX
S. S. Chicago	MLY
S. S. Montcalm	MLZ
S. S. Minnehaha	MMA
S. S. Madonna	MMB
S. S. Majestic	MMC
S. S. Malwa	MMD
S. S. Mantua	MME
S. S. Morea	MMF
S. S. Egypt	MMG
S. S. Moldavia	MMH
S. S. Marie Henriette	MMH
S. S. Charles Roux	MMI
S. S. Mongolia	MMJ
S. S. Minnetonka	MMK
S. S. Macedonia	MML
S. S. Mooltan	MMM
S. S. Minneapolis	MMN
Punta del Este, Uraguay	MMO
S. S. Persia	MMQ
S. S. Marmora	MMR
San Guilano di Trapani, Italy	MMS
S. S. Salsette	MMT
S. S. China	MMU
S. S. Perou	MMV
S. S. Mesaba	MMV
S. S. Minnewaska	MMW
S. S. India	MMY
S. S. Arabia	MMZ
Tug Lorne	MN
S. S. Manitou	MN
S. S. Pannonia	MNA
S. S. Romanic	MNC
North Sydney. Canada	MND
S. S. Menominee	MNE
S. S. Grotius	MNG

S. S. New York	MHK
S. S. Manitou	MNM
S. S. Numidian	MNN
S. S. Oranje	MNO
S. S. Prinses Juliana	MNP
S. S. Marquette	MNQ
S. S. Rembrandt	MNR
Indian Harbor, Labrador	MNR
S. S. Konig Wilhelm III	MNT
S. S. Vondel	MNV
S. S. Konig Wilhelm I	MNW
S. S. Ancona	MOA
S. S. Bologna	MOB
S. S. Oceanic	MOC
S. S. Otrato	MOO
S. S. Sienna	MOE
S. S. Columbia	MOI
S. S. Mongolian	MON
S. S. Ravenna	MOR
S. S. Toscana	MOS
S. S. Taormina	MOT
S. S. Verona	MOV
S. S. Carpathia	MPA
S. S. Empress of Britain	MPB
S. S. Canopic	MPC
S. S. Princess Clementine	MPC
Poldhu, England	MPD
S. S. Lapland	MPD
S. S. Princess Elizabeth	MPE
S. S. Empress of China	MPG
S. S. Philadelphia	MPH
S. S. Princess Henriette	MPH
S. S. Empress of India	MPI
S. S. Empress of Japan	MPJ
S. S. Princess Josephine	MPL
S. S. Empress of Ireland	MPL
Palmaria, Italy	MPM
Capo Sperone, Sardinia, Italy	MPN
Point Amour, Labrador	MPR

Ponza Island, Italy	MPS
S. S. Patris	MPT
S. S. Balmoral Castle	MPW
S. S. Persic	MQC
S. S. Bunker Hill	MR
S. S. Caronia	MRA
S. S. Roma	MRB
S. S. Cretic	MRC
S. S. Sindoro	MRD
S. S. Regina Elena	MRE
S. S. Sannio	MRF
S. S. Regina d'Italia	MRG
S. S. Campania	MRH
S. S. Re d'Italia	MRI
S. S. Ophir	MRJ
S. S. Kawi	MRK
Monte Mario, Rome, Italy	MRM
S. S. Grampian	MRN
S. S. Re Vittorio	MRO
S. S. Principe di Piedmonte	MRP
S. S. Soentuer	MRQ
S. S. Rindjani	MRM
S. S. Tomasodi Savoia	MRS
Three Rivers, Canada	MRS
Father Point, Quebec	MRT
S. S. Principe Umberto	MRU
S. S. Principe di' Udine	MRV
S. S. Willis	MRW
S. S. Tambora	MRY
S. S. Lazio	MRZ
S. S. Ancon	MS
S. S. Massachusetts	MS
S. S. Saxonia	MSA
Cape Sable, Nova Scotia	MSB
Siasconsett, Mass.	MSC
Sable Island, Nova Scotia	MSD
Sea Gate, N. Y.	MSE
S. S San Giovanni	MSF
S. S. San Georgio	MSH
St. John, Pattridge Island, New Brunswick	MSJ
Sagaponack, N. Y.	MSK
Santa Maria di Leuca, Italy	MSL
S. S. St. Louis	MSL
S. S. San Guiseppi	MSN
S. S. Hesperian	MSN
S. S. San Gugliemo	MSO
S. S. St. Paul	MSP
Wellfleet, Cape Cod, Mass.	MSW
S. S. Minto	MT
S. S. Ultonia	MTA
S. S. Teutonic	MTC
Cross Sand lightship, England	MTD
East Goodwin lightship, England	MTE
Gull lightship, England	MTG
S. S. Themistocles	MTH
S. S. Athinai	MTI
Steam yacht Florence	MTK
Sunk lightship, England	MTK
Montreal, Quebec	MTL
S. S. Tunisian	MTN
Torre Piloti di Malamocco, Italy	MTP
S. S. Trotona	MTR
South Goodwin lightship, England	MTS
Tongue lightship, England	MTT
Murdock, Chelsea, Mass.	MU
Musil, Austria-Hungary	MU
S. S. Umbria	MUA
S. S. Titanic	MUC
S. S. Francesca	MUF
S. S. Argentina	MUG
S. S. Alice	MUL

S. S. Sicilian	MUN
S. S. Oceania	MUO
S. S. Laura	MUR
S. S. Sophia	MUS
S. S. Martha Washington	MUW
S. S. Advance	MV
S. S. New Haven	MV
S. S. Argentina	MVA
S. S. Bresilia	MVB
S. S. Italia	MVC
S. S. Vaderland	MVD
Montevideo, Uruguay	MVD
S. S. Europa	MVE
S. S. Savoia	MVF
Venison Island, Labrador	MVI
Steam yacht The Viking	MVK
S. S. Victorian	MVN
S. S. Oceania	MVO
S. S. Viking	MVQ
S. S. Nord America	MVR
S. S. America	MVS
Viesti, Mount Gargano, Italy	MVT
S. S. Venezia	MVZ
S. S. Maurence	MW
Manitowoc, Wis.	MW
Wilhelmshaven, Germany	MW
Vladivostok, Siberia	MW
S. S. Aaro	MWA
S. S. Runic	MWC
S. S. Ionic	MWI
S. S. Athenic	MWN
S. S. Oslo	MWO
Whittle Rocks, Quebec	MWR
Withernsea, England	MWS
S. S. Corinthic	MWT
S. S. Colon	MX
S. S. Medic	MXC
S. S. Afric	MYC
Mazatlan, Mexico	MZ
S. S. Zealandia	MZA
S. S. Bornu	MZB
S. S. Megantic	MZC
S. S. Zeeland	MZD
S. S. Florizal	MZL
S. S. Parisian	MZN
S. S. Rosalind	MZR
Venice, Italty (Arsenal)	MZV
Gjedser Reef lightship, Denmark	N
Nauen, Germany	NA
Cape Elizabeth, Me. (naval station)	NAB
Portsmouth, N. H., (navy yard)	NAC
Boston, Mass. (navy-yard)	NAD
Cape Cod, Highland Light, Mass. (naval station)	NAE
Newport, R. I. (naval station)	NAF
Fire Island, N. Y. (naval station)	NAG
Brooklyn, N. Y. (navy-yard)	NAH
Philadelphia, Pa. (navy-yard)	NAI
Cape Henlopen, Lewes, Del. (naval station)	NAJ
Annapolis, Md. ((Naval Academy)	NAK
Washington, D. C. (navy-yard)	NAL
Norfolk, Va. (navy-yard)	NAM
Pivers Island, Beaufort, N.C. (naval station)	NAN
Charleston, S. C. (navy-yard)	NAO

St. Augustine, Fla. (naval station)	NAP
Jupiter Inlet, Neptune, Fla. (naval station)	NAQ
Key West, Fla. (naval station)	NAR
Pensacola, Fla. (navy-yard)	NAS
New Orleans, La. (naval station)	NAT
San Juan, P. R. (naval station)	NAU
Culebra, W.I. (naval station)	NAV
Guantanamo, Cuba (U. S. naval station)	NAW
Colon, Isthmian Canal Zone (naval station)	NAX
Porto Bello, Isthmian Canal Zone (naval station)	NAY
U. S. S. Ajax	NBH
U. S. S. Alabama	NBI
U. S. S. Albany	NBJ
U. S. S. Alexander	NBM
U. S. S. Arethusa	NBU
U. S. S. Bailey	NCF
U. S. S. Bainbridge	NCG
U. S. S. Baltimore	NCH
U. S. S. Barry	NCK
U. S. S. Biddle	NCM
U. S S. Birmingham	NCN
U. S. S. Brutus	NCT
U. S. S. Buffalo	NCU
U. S. S. Burrows	NCV
U. S. S. Caesar	NCY
U. S. S. California	NCZ
S. S. Northland	ND
U. S. S. Castine	NDA
U. S. S. Celtic	NDB
U. S. S. Charleston	NDC
U. S. S. Chattanooga	NDE
U. S. S. Chauncey	NDF
U. S. S. Chester	NDG
U. S. S. Chicago	NDI
U. S. S. Cincinnati	NDL
U. S. S. Cleveland	NDM
U. S. S. Colorado	NDN
U. S. S. Connecticut	NDQ
U. S. S. Culgoa	NDU
U. S. S. Cyclops	NDY
S. S. Nushagak	NE
U. S. S. Dale	NEH
U. S. S. Decatur	NEJ
U. S. S. Delaware	NEK
U. S. S. Denver	NEM
U. S. S. Des Moines	NEN
U. S. S. Dixie	NEP
U. S. S. Dolphin	NEQ
U. S. S. Don Juan de Austria (Michigan Naval Militia	NER
U. S. S. Drayton	NET
U. S. S. Dubuque	NEU
U. S. S. Eagle	NFC
U. S. S. Farragut	NFP
U. S. S. Flusser	NFS
U. S. S. Galveston	NGD
U. S. S. Georgia	NGF
U. S. S. Glacier	NGH
U. S. S. Goldsborough	NGJ
U. S. S. Gopher (Minnesota Naval Militia)	NGK
U. S. S. Hannibal	NGU
U. S. S. Hartford	NGV
U. S. S. Hector	NGX
U. S. S. Helena	NGY
S. S. Wilhelmina	NH
U. S. S. Hopkins	NHC
U. S. S. Hull	NHE
U. S. S. Idaho	NHN
U. S. S. Illinois	NHO
U. S. S. Indiana	NHQ
U. S. S. Iowa	NHT
U. S. S. Isis	NHU

S. S. Klamath NI
U. S. S. Jupiter NIE
U. S. S. Justin NIF
U. S. S. Kansas NIO
U. S. S. Kearsarge NIP
U. S. S. Kentucky NIQ
U. S. S. Lamson NIW
U. S. S. Lawrence NIY
U. S. S. Lebanon NIZ
U. S. S. Leonidas NJA
U. S. S. Louisiana NJB
U' S. S. Macdonough NJH
U. S. S. Machias NJI
U. S. S. Maine NJL
U. S. S. Marietta NJQ
U. S. S. Mars NJR
U. S. S. Maryland NJS
U. S. S. Massachusetts NJT
U. S. S. Mayrant NJU
U. S. S. Mayflower NJV
U. S. S. McCall NJW
U. S. S. Michigan NJZ
S. S. Pequonock NK
U. S. S. Milwaukee NKA
U. S. S. Minnesota NKD
U. S. S. Mississippi NKE
U. S. S. Missouri NKF
U. S. S. Montana NKM
U. S. S. Monterey NKN
U. S. S. Montgomery NKO
U. S. S. Nanshan NKV
Nantucket Shoals light-ship NLA
Diamond Shoals light-ship NLB
Frying Pan Shoals light-ship NLC
U. S. S. Nebraska NMA
U. S. S. Nero NMB
U. S. S. New Hampshire NME
U. S. S. New Jersey NMF
U. S. S. New Orleans NMG
New York nautical school ship Newport NMH
U. S. S. New York NMI
U. S. S. North Carolina NMN
U. S. S. North Dakota NMO
U. S. S. Ohio NMW
U. S. S. Olympia NMX
Nonendamm, Germany NO
U. S. S. Paducah NOG
U. S. S. Panther NOJ
U. S. S. Patapsco NOL
U. S. S. Patuxent NOM
U. S. S. Paulding NON
U. S. S. Paul Jones NOP
U. S. S. Pennsylvania NOT
U. S. S. Perkins NOX
U. S. S. Perry NOY
Cordova, Alaska (naval station) NPA
Sitka, Alaska (naval station) NPB
Bremerton, Wash. (navy-yard) NPC
Tatoosh Island, Wash. (naval station) NPD
North Head, Wash. (naval station) NPE
Cape Blanco, Oreg. (naval station) NPF
Table Bluff, Cal. (naval station) NPG
North Post, Trinidad NPG
Mare Island, Cal. (navy-yard) NPH
Farallon Islands, Cal. (naval station) NPI
Yerba Buena Island, Cal. (naval station) NPJ
Point Arguello, Cal. (naval station) NPK

Point Loma, Cal. (naval station)	NPL
Honolulu, Hawaii (naval station)	NPM
Guam, Marianas (naval station)	NPN
Cavite, P. I. (naval station)	NPO
Nieuport, Belgium	NPT
S. S. Holland	NQ
U. S. S. Pompey	NQF
U. S. S. Prairie	NQM
U. S. S. Preble	NQN
U. S. S. Preston	NQO
U. S. S. Princeton	NQP
U. S. S. Prometheus	NQR
U. S. S. Rainbow	NRA
U. S. S. Raleigh	NRB
Massachusetts nautical school ship Ranger	NRC
U. S. S. Reid	NRE
U. S. S. Rhode Island	NRI
U. S. S. Decatur	NRJ
U. S. S. Roe	NRM
U. S. S. Salem	NRZ
S. S. New Hampshire	NS
U. S. S. Saturn	NSF
U. S. S. Scorpion	NSG
U. S. S. Smith	NSQ
U. S. S. Solace	NST
U. S. S. South Carolina	NSW
U. S. S. South Dakota	NSX
U. S. S. Sterling	NTA
U. S. S. Sterrett	NTB
U. S. S. Stewart	NTC
U. S. S. St. Louis	NTF
U. S. S. Stringham	NTI
U. S. S. Supply	NTK
S. S. J. S. Chanslor	NU
U. S. S. Tacoma	NUA
U. S. S. Tennessee	NUG
U. S. S. Terry	NUI
U. S. S. Tonopah	NUN
U. S. S. Truxtun	NUS
S. S. Charles S. Nelson	NV
U. S. S. Vermont	NVK
U. S. S. Vestal	NVL
U. S. S. Vicksburg	NVN
U. S. S. Virginia	NVR
U. S. S. Vulcan	NVT
S. S. Northwest	NW
Nawiliwili, Kauai, Hawaiian Islands	NW
U. S. S. Warrington	NWD
U. S. S. Washington	NWE
U. S. S. West Virginia	NWG
U. S. S. Wheeling	NWH
U. S. S. Whipple	NWI
U. S. S. Wilmington	NWK
U. S. S. Wisconsin	NWM
U. S. S. Worden	NWP
U. S. S. Yankton	NXB
U. S. S. Yorktown	NXD
New York ,N. Y. (42 Broadway)	NY
Tug Fearless	N2
S. S. Hamilton	OA
S. S. Atlanta	OAA
S. S Columbia	OAC
S. S. Sophia Hohenberg	OAH
S. S. Princess Anne	OB
S. S. Jamestown	OC
S. S. Jefferson	OD
New York, N. Y. (Herald ship news office, The Battery)	OHX
S. S. Kayo Maru	OKY
Pernambuco, Brazil	OL
S. S. Monroe	OM
U. S. Artillery harbor tug General Randall	OR
S. S. Olivette	OV
S. S. Mascotte	OW
Berlin, Germany	OW

Oxford, England	OX
S. S. Miami	OZ
New York, N. Y. (Hotel Plaza)	P
Isle of Pines, Cuba	P
Seattle, Wash. (University grounds)	PA
S. S. Prince Albert	PA
Ketchikan, Alaska	PB
Pemba Island, Zanzibar	PB
Astoria, Oreg.	PC
Tampa, Fla.	PD
Friday Harbor, Wash.	PD
Port Said, Egypt	PD
Providence, R. I.	PF
Aberdeen, Wash.	PF
Westport, Wash.	PG
Payo Obispo, Mexico	PG
Point Grey, British Columbia	PGD
San Francisco, Cal	PH
Avalon, Catalina Island, Cal.	PI
Fort Frank, P. I.	PIA
Fort Drumm, P. I.	PIB
Fort Wint, P. I.	PIC
Fort William McKinley, P. I.	PID
Point Judith, R. I.	PJ
Los Angeles, Cal. (Boyle Heights)	PJ
San Diego, Cal.	PK
Porthcuno, Cornwall England	PK
Port Tewfik, Egypt	PK
Peking, China (Italian embassy)	PK
Eureka, Cal.	PM
Bahia Blanca, Argentine Republic	PM
Pere Marquette car ferry No. 5	PM5
Alpena, Mich.	PN
Katalla, Alaska	PN
Manila, P. I.	PN
Ponta Negra, Brazil	PNA
Cordova, Alaska	PO
Kronstadt (Fort Menschikoff), Russia	PPZ
Monterey, Cal.	PQ
S. S. City of Chicago	PQ
Parkeston Quay, England	PQL
North Vancouver, British Columbia	PR
Prince Rupert, British Columbia	PRD
San Francisco, Cal. (Presidio)	PS
Port of Spain, Trinidad	PS
Fort Bragg, Cal.	PT
St. Petersburg, Russia	PTB
Bellingham, Wash.	PU
S. S. Mobilla	PU
S. S. Providence	PV
Victoria, British Columbia	PW
Los Angeles, Cal. (Examiner)	PX
Olympia. Wash,	PY
S. S. Enterprise	P1
S. S. Hilonian	P2
S. S. Portland	P3
S. S. Col. E. L. Drake	P4
Standard Oil barge 3	P5
S S. Buckman	P7
S. S. Watson	P8
S. S. Bertha	P9
Quebec	Q
Bluefields, Nicaragua	Q
Alderney, England	QDH
Washington, D. C. (Elliott Woods)	QK
Antwerp, Belgium	QR

Bermuda	QWC
Reggio, Italy	R
S. S. Algerie	RAG
S. S. Governor Cobb	RB
Lightship Recalada, La Plata River, Argentine Republic	RC
U. S. revenue cutter Algonquin	RCA
U. S. revenue cutter Bear	RCB
U. S. revenue cutter Androscoggin	RCD
U. S. revenue cutter Seneca	RCE
U. S. revenue cutter Snohomish	RCF
U. S. revenue cutter Gresham	RCG
U. S. revenue cutter McCullough	RCH
U. S. revenue cutter Itasca	RCI
U. S. revenue cutter Woodbury	RCJ
U. S. revenue cutter Tahoma	RCK
U. S. revenue cutter Tuscarora	RCL
U. S. revenue cutter Mohawk	RCM
U. S. revenue cutter Manning	RCN
U. S. revenue cutter Onondaga	RCO
U. S. revenue cutter Apache	RCP
U. S. revenue cutter Perry	RCQ
U. S. revenue cutter Rush	RCR
U. S. revenue cutter Seminole	RCS
U. S. revenue cutter Thetis	RCT
U. S. revenue cutter Acushnet	RCU
U. S. revenue cutter Windom	RCW
U. S. revenue cutter Yamacraw	RCY
S. S. La Rapide	RD
S. S. France	RFR
S. S. Formosa	RFS
New Haven, England	RHN
S. S. Ile-de-France	RIF
S. S. Russie	RIO
S. S. Italie	RIT
Tug Relief	RJ
Rio de Janeiro, Brazil	RJ
Rijo, Brazil	RJI
Corkbeg, England	RJF
Santa Rosalia, Mexico	RH
S. S. Plata	RLA
S. S. Puritan	RN
S. S. Calvin Austin	RN
S. S. Atrato	RNA
Magdalena	RND
S. S. Nile	RNJ
S. S. Clyde	RNK
S. S. Thames	RNM
S. S. Orinoco	RNO
S. S. Ortona	RNQ
S. S. Trent	RNR
S. S. Tagus	RNS
S. S. Orotava	RNV
S. S. Oruba	RNU
S. S. Berbice	RNX
S. S. Premier	RP
S. S. Pampa	RPP
S. S. Parana	RPR
S. S. I. J. Merritt	RQ
S. S. Marquette	RQ

Dover, England	RQW
Rixhoft, Germany	RRX
S. S. Rescue	RS
Pinar del Rio, Cuba	RS
Rost, Norway	RST
Port Arthur, Tex.	RU
S. S. Governor Dingley	RV
U. S. Artillery Harbor Tug Captain Rowell	RW
Mexican cable ship Relay	RX
S. S. Yale	RY
Raza, Brazil	RZA
Cambridge, Mass.	S
S. S. Salvor	SAL
S. S. Satellite	SAT
S. S. Prinz August Wilhelm	SB
S. S. Birma	SBA
S. S. Indiana	SC
S. S. Tasco	SC
Bari, Italy	SC
S. S. J. F. Tietgen	SCF
Scheveningen, Holland	SCH
Felixstowe, England	SCQ
S. S. Estonia	SEA
San Franciso, Cal.	SF
S. S. Prinz Eitel Frederich	SF
S. S. Prinz Sigismund	SG
Sault Ste. Marie, Mich.	SH
S. S. Oceana	SK
Cape Lazo, B. C.	SKD
Skegness, England	SKE
San Jose del Cabo, Mexico	SJ
S. S. Litunia	SLA
S. S. Sierra	SM
Ponta Delgado, San Miguel, Azores	SMG
Windmill Hill, Gibraltar	SMP
Charleston, S. C. (Hampton Park)	SN
Santiago de Cuba, Cuba	SN
Barge Shenango	SNA
S. S. Wm. P. Porter	SND
S. S. Wilpen	SNW
S. S. King Oscar II	SOR
Sorvaagen, Norway	SOT
S. S. Prinz Joachim	SP
S. S. Russia	SRN
S. S. Puritan	SQ
S. S. Stanley	ST
Santa Maria, Azores	STM
Savannah, Ga.	SV
Southwest Pass, La.	SW
Seattle, Wash.	S2
Cherbourg, France	TCF
S. S. Chito Maru	TCY
Dunkerque, France	TDF
Tobermory Island, Scotland	THM
S. S. Hong Kong Maru	THN
Triangle Island, British Columbia	TLD
Lorient, France	TLF
Port Patrick, England	TLK
S. S. America Maru	TMC
Tjomo, Norway	TMO
Rame Head, England	TMP
S. S. Tennessee	TN
Tienstin, China	TN
S. S. Nippon Maru	TNP
Oran, Algeria	TOF
Brest, France	TQF
S. S. Rosina	TR
Rochefort, France	TRF
S. S. Tenyo Maru	TTY
Tempelhofer, Germany	TU
Kiel, Germany (torpedo station)	TVK
Scilly Islands, England	TVP
Tangiér, Morocco	TW
Portland, England	TWQ
New York, N. Y., (111 Broadway)	TWT
S. S. Jos. Vacarro	TY

Tacoma, Wash.	T2
S. S. Ellis	UA
S. S. Preston	UB
Boulogne, France	UBL
S. S. Buffalo	UBO
S. S. Cartago	WC
S. S. Ucayali	UCL
S. S. Lansing	UD
S. S. Parisiana	UD
S. S. Idaho	UDI
Rama, Nicaragua	UE
S. S. Admiral Schley	UG
S. S. Galilee	UGO
S. S. Heredia	UH
S. S. Herman Frasch	UHF
S. S. Noruega	URG
S. S. Highland Laddie	UHL
S. S. Highland Pride	UHP
S. S. Highland Rover	UHR
Cape San Antonio, Cuba	UJ
S. S. Acre	UJA
S. S. Sergipe	UJB
S. S. Orion	UJC
S. S. Bahia	UJG
S. S. Marnhao	UJH
S. S. Olinda	UJI
S. S. Brazil	UJK
S. S. San Salvador	UJM
S. S. Goyaz	UJN
S. S. Para	UJO
S. S. Saturno	UJP
S. S. Manaos	UJQ
S. S. Jupiter	UJR
S. S. Ceara	UJV
S. S. Alagoas	UJY
S. S. Sirio	UJZ
S. S. Turralba	UK
S. S. Huallaga	ULA
S. S. Santa Maria	UM
S. S. Antenas	UM
S. S. Druid	UMD
Ouessant, France	UOS
S. S. Prince George	UPG
Porquerolies France	UPQ
S. S. Prince Rupert	UPR
S. S. Santa Rita	US
Estevan Point, B. C.	USD
S. S. Eskimo	USK
St. Marie de la Mer, France	USM
S. S. St. Vincent	USV
S. S. Admiral Dewey	UV
S. S. Verdi	UVD
S. S. Vasari	UVR
S. S. Admiral Farragut	UW
S. S. Pectan	UW
S. S. San Paulo	UWK
S. S. Minas Geraes	UWN
S. S. Rio de Janeiro	UWR
S. S. Texas	UXS
S. S. Lurline	U2
San Giovanni, Italy	V
S. S. Apache	VA
S. S. Arapahoe	VB
S. S. Comanche	VC
S. S. Villa de Douvres	VD
Yacht Vanadis	VDS
S. S. Iroquois	VF
Sheerness, England	VFM
S. S. Algonquin	VG
S. S. Huron	VH
S. S. Seminole	VJ
S. S. Cherokee	VK
Wyl lightship, Denmark	VL
S. S. Mohawk	VM
Victoria, British Columbia	VSD
Victoria, British Columbia	V2
New York, N. Y. (Waldorf-Astoria)	WA
S. S. China	WA
S. S. W. B. Davock	WB
S. S. Beaver	WB
Wiborg, Italy	WB

S. S. Morro Castle	WC
S. S. Bear	WD
Bayonne, N.J.	WD
S. S. City of Lowell	WE
S. S. Manchuria	WE
Escuela Naval, Chile	WEN
Playa Ancha, Chile	WFT
S. S. Seguranca	WG
S. S. Havana	WH
S. S. Korea	WK
Las Salinas, Chile	WLS
S. S. Merida	WM
S. S. Mongolia	WN
Wilsons Point, Conn.	WN
Eastport, Me.	WQ
S. S. City of Traverse	WQ
New London, Conn.	WS
S. S. Asia	WT
S. S. Siberia	WU
S. S. Vigilancia	WV
S. S. Mexico	WX
S. S. Monterey	WY
Motor yacht Sea Otter	WY
S. S. Esperanza	WZ
U. S. Artillery harbor tug Reno	X
Port Limon, Costa Rico	X
S. S. Hendrick Hudson	XA
S. S. Arizona	XA
S. S. City of Philadelphia	XA
New York, N. Y. (66 Broadway)	XAS
New York, N. Y. (Metropolitan tower)	XAV
S. S. City of Wilmington	XB
S. S. Robert Fulton	XB
Philadelphia, Pa.	XBG
Washington, D. C. (Evans Building)	XBM
S. S. Walter Adams	XD
S. S. Florida	XF

S. S. Alabama	GX
S. S. Virginia	XK
S. S. Alaska	XK
Duluth, Minn.	XKA
Houghton, Mich.	XKD
Sault Ste. Marie, Mich.	XKG
Cheboygan, Mich.	XKJ
Toledo, Ohio	XKS
Cleveland, Ohio	XKW
S. S. Mindora	XM
Escanaba, Wis.	XMB
Milwaukee, Wis.	XMH
Chicago, Ill.	XMJ
Michigan City, Ind.	XMQ
Ludington, Mich.	XMV
S. S. J. L. Lawrence	XN
S. S. City of Norfolk	XN
S. S. City of Baltimore	XO
Xcalac, Mexico	XP
S. S. Louise	XQ
S. S. Quick Step	XQ
S. S. Jos. Wharton	XW
S. S. S. V. Luckenbach	YA
S. S. Paraguay	YA
S. S. Thalia	YA
S. S. Aki Maru	YAK
S. S. Awa Maru	YAW
S. S. Toledo	YD
S. S. Inaba Maru	YIB
S. S. Iyo Maru	YIY
S. S. Kaga Maru	YKG
S. S. Illinois	YN
S. S. Shinano Maru	YSN
S. S. Tamba Maru	YTB
S. S. Tango Maru	YTG
S. S. Toso Maru	YTS
S. S. Ossabow	ZB
S. S. Ogeechee	ZK
S. S. Satilla	ZM
S. S. Altamaha	ZQ
Zanzibar	ZR
S. S Ocmulgee	ZU